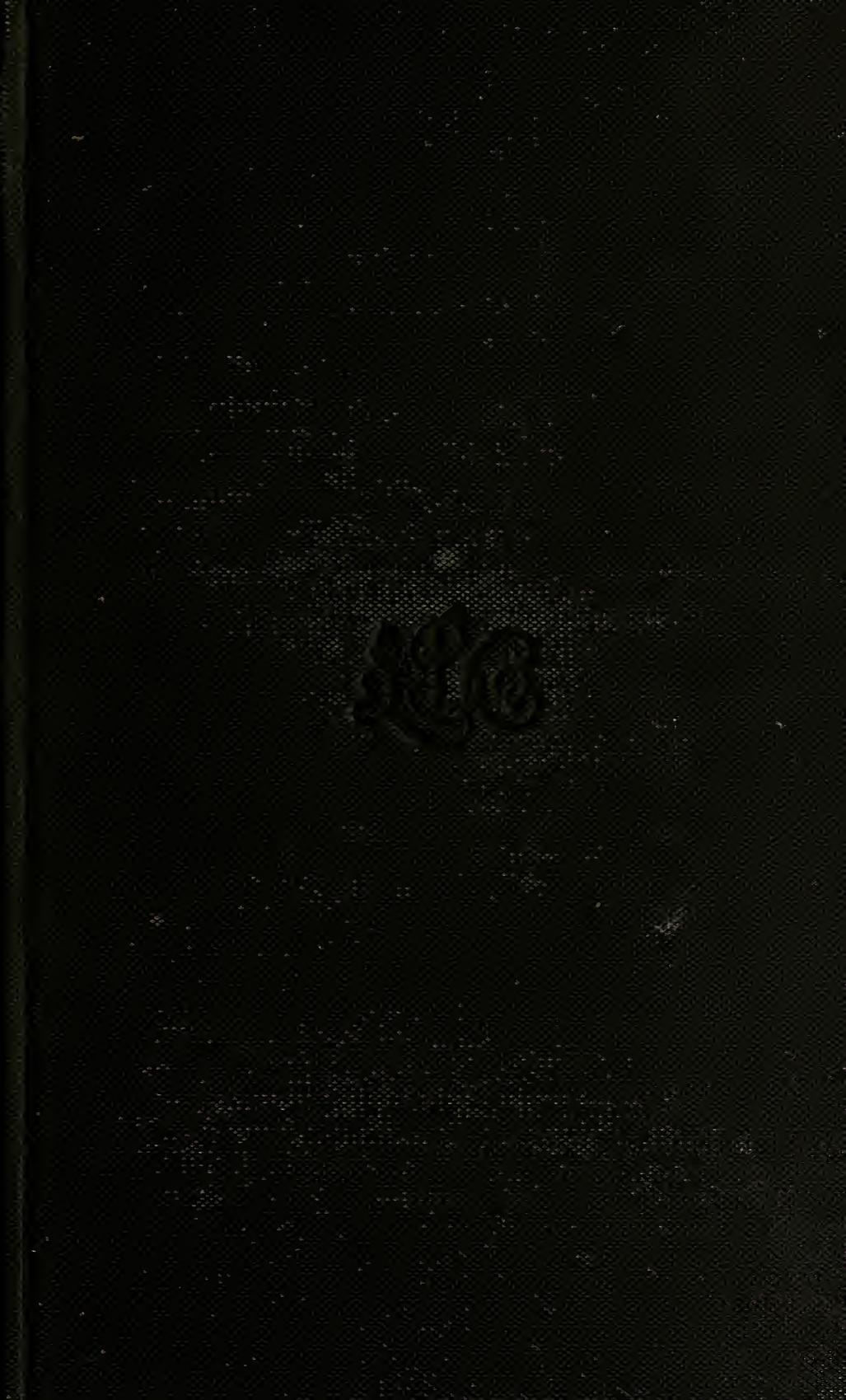


Class RD731

Book .W618

Copyright No.

COPYRIGHT DEPOSIT.

A TREATISE

ON

ORTHOPÆDIC SURGERY

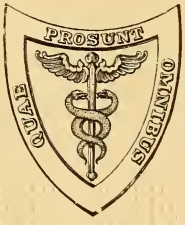
BY

ROYAL WHITMAN, M.D.

Instructor in Orthopædic Surgery and Chief of the Orthopædic Department of the Vanderbilt Clinic in the College of Physicians and Surgeons of Columbia University; Adjunct Professor of Orthopædic Surgery in the New York Polyclinic; Assistant Surgeon and Chief of Clinic at the Hospital for Ruptured and Crippled; Orthopædic Surgeon to the Hospital of St. John's Guild.

Member of the Royal College of Surgeons of England; Member and Sometime President of the American Orthopedic Association; Corresponding Member of the British Orthopædic Society; Member of the New York Surgical Society, Etc.

ILLUSTRATED WITH FOUR HUNDRED AND FORTY-SEVEN ENGRAVINGS



LEA BROTHERS & CO.
PHILADELPHIA AND NEW YORK
1901

THE LIBRARY OF
CONGRESS,
TWO COPIES RECEIVED
APR. 11 1901
COPYRIGHT ENTRY
Apr. 11. 1901
CLASS a XXc. No.
6974
COPY B.

Entered according to the Act of Congress in the year 1901, by

LEA BROTHERS & CO.

In the Office of the Librarian of Congress. All rights reserved.

TO

VIRGIL P. GIBNEY, M.D., LL.D.

THIS VOLUME IS INSCRIBED

AS A TOKEN OF FRIENDSHIP ASSURED BY LONG ASSOCIATION,

AND OF APPRECIATION OF HIS EFFORTS

FOR THE ADVANCEMENT OF

ORTHOPÆDIC SURGERY

PREFACE.

The student of Orthopædic Surgery is especially concerned with the mechanics of the human machine, with its development, with its capacity at different periods of life and under varying conditions, and with those affections that lead to deformity or that otherwise impair its usefulness. He is concerned, moreover, not only with the local and immediate effects of disease or disability, but also with its general influence upon the entire mechanism, and with its ultimate consequences as well.

Orthopædic Surgery occupies a broad field and one of very great and general interest. Its most distinctive advance in recent years has been toward the prevention of deformity, an advance that has been made possible by the better understanding of its predisposing and exciting causes. As a natural consequence, treatment has become more direct, more simple, and more effective. It has been the purpose of the author to emphasize this aspect of the subject, which is of the greatest importance to the general practitioner, who so often has the opportunity to recognize disease or disability in its incipiency, when its progress may be checked by timely treatment.

He has endeavored to present Orthopædic Surgery as far as possible objectively, a method which has proved acceptable to students and practitioners in clinical teaching; thus the selection of each subject and the space that has been allotted to it has been determined primarily by its relative importance in the actual work of Orthopædic clinics. He has been at some pains, also, to outline methods of examination, to explain the phenomena of the symptoms and so to describe and to illustrate the causes and effects of disease and disability as to indicate, in natural sequence, the principles of treatment. The particular methods of the application of those principles, which have always been described in detail, are those that have been tested by personal experience.

Although this book is designed particularly for students and practitioners of medicine, the author has included statistical and other data

which he hopes may prove of interest to his fellow-workers in this special field.

The author desires to express his obligation to the gentlemen who have assisted him in the collection of statistics, and otherwise, whose names are mentioned in the text; to Dr. L. W. Ely and to Mr. W. P. Agnew for timely photographs, and especially to the Trustees of the Hospital for Ruptured and Crippled, for the facilities that have been afforded him in the preparation of this work. R. W.

New York, 1901.

CONTENTS.

CHAPTER I.

TUBERCULOUS DISEASE OF THE SPINE.

Description — Pathology — Etiology — Statistics — General prognosis—Symptoms—Physical examination—Contour and flexibility of the spine—Divisions of the spine—Landmarks—The differential diagnosis of disease in the lower, middle and upper regions of the spine—Treatment by horizontal fixation—by braces—by jackets—by other means. The selection and adaptation of treatment for disease of the different regions of the spine. The complications of tuberculous disease of the spine—Abscess — course — symptoms — treatment. Paralysis—course—symptoms—treatment. Forcible correction of deformity—(Calot's operation)—Gradual correction of deformity.... 17

CHAPTER II.

NON-TUBERCULOUS AFFECTIONS OF THE SPINE.

Syphilis—Malignant disease—Osteomyelitis—Actinomycosis—Injury—Traumatic spondylitis—Rhachitic spine—Typhoid spine—Gonorrhœal "rheumatism" of the spine—Arthritis—Spondylitis deformans—Osteitis deformans—Neurotic spine—Hysterical spine—Spondylolisthesis—Sciatic scoliosis—Sacro-iliac disease..... 107

CHAPTER III.

LATERAL CURVATURE OF THE SPINE.

Description—habitual and fixed deformity, rotation and lateral deviation. Pathology — Etiology — Statistics —Varieties — Distribution and effects of deformity —Symptoms—Diagnosis—Prognosis—Prevention of deformity—Treatment—by exercises—general exercises—heavy exercises—special exercises—Supports. Forcible correction of deformity—Adjuncts in treatment—Duration of treatment. 120

CHAPTER IV.

DEFORMITIES OF THE SPINE, CONTINUED. DEFORMITIES OF THE CHEST. FUNCTIONAL PATHOGENESIS OF DEFORMITY.

Varieties in contour of the spine—Kyphosis—Lordosis—Congenital elevation of the scapula—Absence of vertebræ—Flat chest—Pigeon

chest—Funnel chest—Absence of ribs—Defective formation of the pectoral muscles—Absence or defect of the clavicle—Acquired luxation or subluxation of the clavicle—Asymmetrical development—Tables of height, weight, and circumference of the chest—Functional pathogenesis of deformity—(Wolff's law)..... 181

CHAPTER V.

TUBERCULOUS DISEASE OF THE BONES AND JOINTS.

Predisposition—Mode of infection—Latent tuberculosis—Local predisposition—Statistics—distribution of disease—location—side affected—sex—age. Pathology—Varieties of disease—Method of repair—Prognosis—Treatment—operative and mechanical—by drugs—local applications—venous stasis (Bier's treatment)..... 194

CHAPTER VI.

NON-TUBERCULOUS DISEASES OF THE JOINTS.

Syphilitic disease of joints—Gonorrhœal arthritis—Other forms of infectious arthritis—Acute epiphysitis—Localized infectious osteomyelitis—Osteo-arthritis— Hæmophilia — Hæmarthrosis — Scorbutus—Charcot's disease—Anchylosis..... 206

CHAPTER VII.

TUBERCULOUS DISEASE OF THE HIP JOINT.

Pathology—Statistics—Symptoms—Physical signs, distortion, apparent lengthening, apparent shortening. Causes of distortion—Atrophy—Causes of actual shortening—Measurements—Lovett's table—Kingsley's table—Differential diagnosis—Principles of treatment—The traction hip brace—The Thomas brace—The plaster bandage—Various methods of reducing deformity—The long hip splint—Other forms of apparatus—Double hip disease—Abscess—statistics—treatment—Operative treatment—exploration—excision—reduction of resistant deformity—Prognosis, mortality, functional results. Secondary deformities of hip disease—Final results..... 221

CHAPTER VIII.

NON-TUBERCULOUS AFFECTIONS OF THE HIP JOINT.

Traumatisms at the hip—Acute infectious arthritis—Extra-articular disease—Malignant disease at the hip joint—Cysts of the femur—Arthritis deformans..... 300

CHAPTER IX.

TUBERCULOUS DISEASE OF THE KNEE JOINT.

Pathology—Etiology—Statistics—Symptoms, primary and secondary distortions—Diagnosis—Differential diagnosis—Treatment—mechan-

ical — Extra-articular disease—Abscess — Operative treatment—arthrectomy—excision, amputation—Prognosis—mortality—functional results—General conclusions 304

CHAPTER X.

NON-TUBERCULOUS AFFECTIONS OF THE KNEE JOINT.

Injury in childhood—Synovitis—Infectious arthritis—Osteo-arthritis—Prepatellar bursitis—Pretibial bursitis—Bursæ and cysts in the popliteal region—Internal derangement of the knee joint—Congenital genu recurvatum—rudimentary or absent patella—Congenital displacement of patella—Slipping patella—Elongation of the ligamentum patellæ—Snapping knee—Congenital contraction at the knee—General contractions—Acquired genu recurvatum..... 324

CHAPTER XI.

DISEASES AND INJURIES OF THE ANKLE JOINT.

Tuberculous disease—Pathology—Etiology—Statistics—Symptoms—Diagnosis—Treatment—Prognosis—Tuberculous disease of the tarsus—Statistics—Treatment—Sprain of the ankle—Teno-synovitis—Other affections of the ankle joint..... 334

CHAPTER XII.

DISEASES AND INJURIES OF THE ARTICULATIONS OF THE UPPER EXTREMITY.

Tuberculous disease of the shoulder joint — Pathology — Statistics—Symptoms—Treatment—Prognosis—Tuberculous disease of the elbow joint — Pathology—Statistics—Symptoms—Treatment—Prognosis—Tuberculous disease of the wrist joint—Symptoms—Treatment—Prognosis—Spina ventosa—Periarthritis of the shoulder joint—Chronic bursitis at the shoulder—Sprain of the wrist—Acute teno-synovitis at the wrist..... 348

CHAPTER XIII.

CONGENITAL AND ACQUIRED AFFECTIONS LEADING TO GENERAL DISTORTIONS.

Rhachitis—Etiology—Pathology—Symptoms, deformities—Prognosis—Treatment—"Late rickets"—"Fœtal rhachitis"—Infantile scorbutus—Fragilitas ossium—Osteomalacia—Osteitis deformans—Secondary hypertrophic osteo-arthropathy—Acromegalia..... 361

CHAPTER XIV.

CONGENITAL DISLOCATION OF THE HIP AND COXA VARA.

Congenital dislocation of the hip joint—Statistics—Pathology—Etiology—Symptoms—Diagnosis—Differential diagnosis—Treatment—the

open operation—the Lorenz operation—the intermediate operation—secondary osteotomy—Palliative treatment—Coxa vara—Pathology—Etiology—Statistics—Symptoms—Diagnosis—Treatment—mechanical—operative. Fracture of the neck of the femur—Traumatic separation of the epiphysis of the head of the femur 373

CHAPTER XV.

DEFORMITIES OF THE BONES OF THE LOWER EXTREMITY.

Bow leg—Knock knee—Statistics—Etiology—The outgrowth of deformity—Genu valgum—Description—Attitudes—Secondary deformities—Gait—Unilateral deformity—Pathology—Treatment—expectant—mechanical—operative—Genu varum, Varieties—Symptoms—Treatment—Expectant—mechanical—operative—Anterior bow leg—General rhachitic distortions..... 405

CHAPTER XVI.

DEFORMITIES OF THE UPPER EXTREMITY.

Congenital dislocation of the shoulder—Obstetrical paralysis—Recurrent dislocation of the shoulder—Congenital deformities of the elbow—Cubitus valgus—Cubitus varus—Subluxation of the wrist—Club hand—Varieties—Club hand associated with defective development—Congenital contraction of the fingers—Webbed fingers—Trigger finger—Mallet finger—Baseball finger—Dupuytren's contraction 430

CHAPTER XVII.

DISEASES OF THE NERVOUS SYSTEM.

Acute anterior poliomyelitis—Pathology—Etiology—Statistics—Symptoms—Causes of deformity—Deformity in various regions—Subluxation—Retardation of growth—Treatment, mechanical, operative... 440

CHAPTER XVIII.

DISEASES OF THE NERVOUS SYSTEM, CONTINUED.

Cerebral paralysis of childhood—Description—Distribution—Etiology—Pathology—Symptoms—Congenital paralysis—Acquired paralysis—Treatment—Prognosis—Progressive muscular atrophy—Varieties—Symptoms—Hereditary ataxia—Neuritis—Functional affections of the joints—"Hysterical" hip—Differential diagnosis—"Hysterical" club foot—"Hysterical" scoliosis—Neurotic joints..... 459

CHAPTER XIX.

CONGENITAL AND ACQUIRED TORTICOLLIS.

Description—Statistics—Congenital torticollis—Etiology—Hæmatoma of the sterno-mastoid muscle—Acquired torticollis—Varieties—Acute

torticollis—Etiology—Symptoms—Diagnosis—Treatment of torticollis—chronic, acute—Spasmodic torticollis—Etiology—Pathology—Treatment—Exceptional forms of torticollis—paralytic—diphtheritic—cervical opisthotonos, rhachitic—ocular—psychical..... 474

CHAPTER XX.

DISABILITIES AND DEFORMITIES OF THE FOOT.

General description of the foot and of its functions, the arches, the foot as a passive support, in activity—Improper postures—Movements—Function of the muscles—Strength of the muscles—The foot as a mechanism—The weak foot or so-called flat foot—Description—Anatomy—Pathology—Etiology—Statistics—Symptoms—Diagnosis—Varieties—Weak foot in childhood—Treatment, preventive—Exercises—Support—Construction of brace—The rigid weak foot—Forcible correction of deformity—Subsequent treatment—Adjuncts in treatment—Operative treatment..... 492

CHAPTER XXI.

DISABILITIES AND DEFORMITIES OF THE FOOT, CONTINUED.

The hollow foot—Anterior metatarsalgia—Achillo bursitis—Achillo-bursitis posterior—Strain of the tendo Achillis—Calcaneo-bursitis—Plantar neuralgia—Erythromelalgia—Hallux rigidus—Hallux varus—Pigeon toe—Hallux valgus—Hammer toe—Overlapping toes—Exostoses—Displacement of the peronei tendons—Shoes, effects of improper shoes—Demonstration of the proper shoe..... 530

CHAPTER XXII.

DEFORMITIES OF THE FOOT.

Talipes—Description—Varieties—Statistics of talipes, congenital and acquired—Relative frequency of the different varieties—Congenital talipes—Etiology—Anatomy—Symptoms—Principles of treatment of infantile club foot—Treatment—mechanical—by plaster bandage—by braces—restoration of function—supervision—Treatment in older subjects—forcible manual correction—tenotomy—Wolff's treatment, reduction of deformity by wrenches—Phelps' operation—Operations on the bones—Mechanical treatment—Other varieties of congenital talipes—varus—equinus—calcaneus—valgus—equino-valgus — calcaneo-valgus — calcaneo-varus — equino-cavus—valgo-cavus—cavus— Congenital talipes associated with defective development—with absence of fibula—with absence of tibia—with defective formation of the foot—Constricting bands—Congenital amputation—Congenital œdema—Spina bifida and talipes..... 560

CHAPTER XXIII.

DEFORMITIES OF THE FOOT, CONTINUED.

Acquired talipes—Etiology—Diagnosis—Talipes equinus—Description—Etiology—Symptoms—Treatment—mechanical—operative—Talipes calcaneus—Description, development of deformity—Symptoms—Treatment—mechanical, operative—Willett's operation—astragalectomy—Talipes equino-varus and talipes equino valgus—Other varieties of acquired talipes—Tendon transplantation in the treatment of paralytic talipes—Tendon splicing—Arthrodesis..... 609

ORTHOPÆDIC SURGERY.

CHAPTER I.

TUBERCULOUS DISEASE OF THE SPINE.

Synonym.—Pott's Disease.

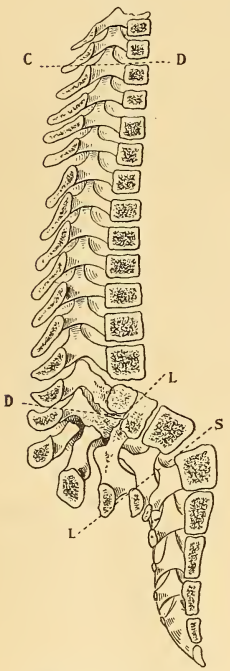
Pott's disease is a chronic destructive ostitis of the bodies of the vertebræ which form the anterior or weight-supporting portion of the spinal column. As the disease progresses the spine bends at the weakened point, and the upper part, sinking downward and forward, throws into relief the spinous processes at the seat of disease; thus an angular posterior projection is formed. It is called Pott's disease because such deformity, slow in formation, accompanied by pain and sometimes by paralysis, was first described accurately by Percival Pott, in 1779. Angular deformity is, however, simply the evidence of destruction of a portion of the anterior part of the vertebral column. Thus it might be the result of fracture, or of the erosion of an aneurism, or of malignant disease, or syphilis or other pathological process; but deformity from such causes is not now included under Pott's disease, nor is the term now synonymous with deformity. In the modern sense it signifies tuberculous disease of the bodies of the vertebræ, of which the early symptoms may be detected and of which the deforming effects may be checked and even prevented by proper treatment. The compression and collapse of the affected parts cause the characteristic angular projection at the seat of disease. If one vertebral body is destroyed the projection will be sharp; if several are implicated it will be less angular, and if one side of a body breaks down before the other there may be a lateral as well as a posterior distortion.

The size of the deformity and its effect upon the individual depend in great degree upon its situation. If the disease is at either extremity of the spine the angular projection must be small because so little of the column remains beyond the destructive process; or in other words, the area of the spine directly involved in the deformity is small compared to that which is free from disease. Thus the characteristic deformity in the upper cervical region shortens the neck and disturbs the poise of the head; in the lower lumbar region it shortens the trunk and induces a peculiar attitude and gait. In either case the actual local deformity is usually insignificant and the distortion of the body is comparatively slight. But when the middle of the spine is involved, the opportunity for deformity is great because the entire

column may enter into the formation of the angular kyphosis; thus the internal organs are compressed and the effect upon the vital mechanism is disastrous.

Pott's disease, as contrasted with tuberculosis of other bones and joints, is peculiar in that it is concealed from view, in that direct surgical intervention is of comparatively little avail, in that it lies in close proximity to important parts, the spinal cord behind and the vital organs in front, and finally, in that the effects of the disease and deformity are not limited to the parts directly involved, but influence, to a greater or less degree, the entire mechanism of the body.

FIG. 1.



Destruction of the bodies of the first, second and third lumbar vertebræ—with the resulting deformity. (MÉNARD.)

Pathology.—The minute changes that characterize tuberculosis of bone in general are described in Chapter V.

The first indication of the disease is usually found in the anterior part of a vertebral body just beneath the fibro-periosteal layer of the anterior longitudinal ligament. From this point the granulation tissue advances along the front of the spine and, following the course of the blood vessels, it invades and destroys the adjacent vertebral bodies. In other instances the disease may begin in the interior of a vertebral body, most often in several minute foci near the upper or lower epiphysis. These coalescing, gradually enlarge, forming a cavity, surrounded for a time by unbroken cortical substance, which becoming weaker collapses under the pressure of the superincumbent weight. Occasionally the disease advances beneath the anterior ligament without implicating deeply the substance of the bone, a form of tuberculous periostitis, "spondylitis superficialis."

The inter-vertebral discs appear to offer some resistance to the extension of the disease from one vertebra to another, but when the bone is destroyed on either side they quickly disintegrate and disappear. The posterior part of the spinal column usually remains practically free from disease with the exception of the pedicles and articulations which may be in direct contact with the tuberculous process. In rare instances the disease may begin in a lamina or spinous process, or one of the small joints may be primarily involved, but such forms of local tuberculosis would hardly be classed as Pott's disease unless the anterior part of the spine were implicated also.

The course and outcome of the disease depends upon its type. In one instance the area of primary infection is small and the local resistance is sufficient to check its further progress, so that cure without

deformity may follow; or it may advance slowly, accompanied by a process of repair; the area of active disease is small and the granulation tissue undergoes a fibroid transformation or becomes ossified. In such cases deformity may appear and slowly increase, practically without symptoms. In most instances however, the tuberculous granulations advance more rapidly, destroying the bone or other tissue with

Fig. 2.

Pott's disease.

which they come in contact; the usual retrograde metamorphosis to cheesy degeneration follows and very frequently liquefaction or abscess formation; the latter change being caused possibly by secondary infection with pyogenic germs. Clinically the liability to abscess is very much increased by irritation or injury and is decreased by absolute rest of the diseased part.

As a rule, in those cases of moderate severity, that come to autopsy during the progressive stage of the disease, one finds on dividing the thickened tissues in front of the spine, a cavity, the walls of which are lined with tuberculous granulations in various stages of degeneration, and containing puriform fluid. The adjoining vertebral bodies present a worm-eaten appearance and one or more of them is partially destroyed. Small fragments of necrosed bone and "bone sand" may be present, together with larger masses of degenerated tissue; in rare instances sequestra of considerable size may be found.

Occasionally the disease may begin in the posterior part of a vertebral body, or it may extend backward as well as forward, and, forcing its way into the vertebral canal, it may press upon the spinal cord and involve its coverings, and thus cause paralysis of the parts below. Less often pressure on the cord may be due to the presence of an abscess or to a projecting fragment of bone.

The calibre of the spinal canal may be constricted somewhat by the pressure of the superincumbent weight upon the softened and thickened tissues at the seat of disease, but as a rule, its capacity is not directly lessened by the angular distortion nor does the degree of deformity directly influence the frequency of paralysis.

Although the disease may begin in multiple primary foci of infection over an extended area, or in two or more distinct regions of the spine simultaneously, yet clinical observation seems to show that it is, in most instances, originally confined to one or two adjacent bodies, one or both of which are partially destroyed; from this central point the disease may extend in either direction until half the spine may be implicated, but in ordinary cases the final area of deformity and rigidity shows that from three to six bodies are more or less involved before cure is established.

If the disease is limited in extent, the eroded surfaces of the adjoining vertebræ may come into direct contact, but if several vertebral bodies have been destroyed the upper portion of the spine as it sinks downward is often displaced backward so that the anterior aspect of one or more of the upper segments may be apposed to the superior surface of the first body of the lower section (Fig. 3). Less often there may be forward displacement of the upper part upon the lower (Fig. 1).

At all stages of the disease resistance to its progress, and efforts at repair are evident in the affected parts. When this resistance overbalances the tendency to degeneration, cure follows.

Repair is accomplished occasionally by contact and solid union of the adjoining surfaces of softened bone, but usually the anchylosis is in part fibrous, in part cartilaginous and in part bony, and this union may be further strengthened by a callous formation from the thickened tissues about the seat of disease.

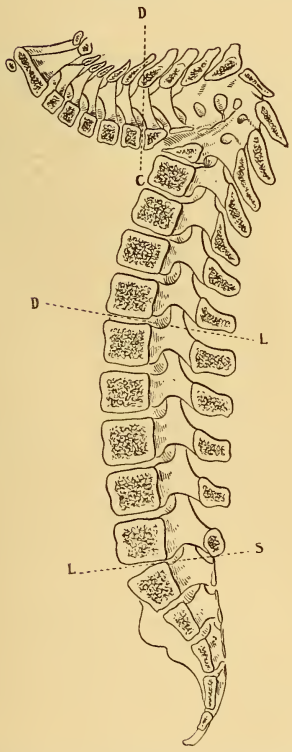
In many instances the articular processes, the pedicles and laminæ become anchylosed before repair has advanced appreciably in the anterior portion of the column.

Cure may be absolute, as when no vestige of the disease remains;

it may be practically complete, as when the diseased products undergo calcareous degeneration and are shut in by a layer of solid bone. In other instances the disease becomes quiescent or but slowly advances, showing its presence by exacerbations of pain or by the formation of an abscess, long after active symptoms have ceased.

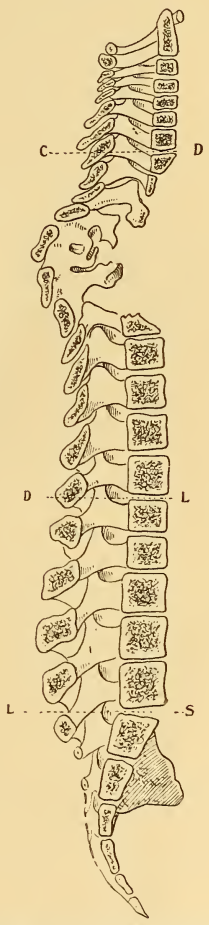
Etiology.—The etiology of tuberculosis of the spine does not differ

FIG. 3.



Destruction of the bodies of the third, fourth, fifth, sixth and seventh dorsal vertebræ; partial destruction of three others. (MÉNARD.)

FIG. 4.



The deformity corrected showing the area of the destructive process. (MÉNARD.)

from that of tuberculosis of other bones; the subject is considered in Chapter V.

Relative Frequency.—Tuberculosis of the spinal column is more common than of any other single bone or joint, as might be expected from its greater area. This point is illustrated by the statistics of tuberculous disease treated in the out-patient department of

the Hospital for Ruptured and Crippled, New York, during a period of fifteen years, 1885–1899.

Tuberculosis of the Spine	3,207 cases.
" " " Hip	2,230 "
" " other joints inclusive	2,408 "

Also by similar statistics contained in a recent report of the Boston Children's Hospital, for a longer period, 1869–1893.

Tuberculosis of the Spine	1,864 cases.
" " " Hip, Knee, Ankle, Shoulder, Elbow and Wrist combined	1,856 "

Age.—Pott's disease, although far more frequent in the middle period of childhood, from the third to the tenth years, may occur at any time from earliest infancy to extreme old age.

In a series of 1,259 consecutive cases of tuberculosis of the spine collected from the records of the outdoor department of the Hospital for Ruptured and Crippled, New York, analyzed for me by Drs. R. T. Frank and C. Gunter, the ages of the patients at the supposed time of onset of the disease appeared to be as follows :

Less than 1 year			38	3.1	per cent.
Between 1	and	2 years.	176	14.2	"
" 3	"	5 "	627	50.2	"
" 6	"	10 "	234	18.3	"
" 11	"	20 "	89	7.2	"
" 21	"	30 "	43	3.5	"
" 31	"	50 "	31	2.6	"
Over 50		"	11	.8	"

The youngest patient was two months old, the oldest seventy-one years.

Dr. Thorndike,[1] of Boston, from the records of the Boston Children's Hospital for thirteen years, 1883 to 1896, collected 115 cases of tuberculosis of the spine in children of two years or less. Seven of these were less than six months, and twenty were under one year in age.

Mr. Howard Marsh [2] has called attention to Pott's disease of the aged, and cites three cases in subjects of sixty or more years of age.

Sex.—Sex exercises comparatively little influence on the liability to disease of this region. Of 3,797 cases collected by Mohr, Gibney, Fischer, Taylor and Bradford and Lovett, quoted by Hoffa, 2,045 were in males and 1,752 were in females. Of 1,367 cases collected by Frank and Gunter, 708 (52 per cent.) were in males and 659 (48 per cent.) were in females ; and in 2,455 cases tabulated by Knight 1,329 were in males and 1,126 in females. In these combined cases from the Hospital for Ruptured and Crippled 3,822 in number, 53.2 per cent. were in males and 46.8 per cent. in females.

The Situation of the Disease.—The dorso-lumbar section of the spine is most often affected. Cervical ostitis is comparatively infrequent.

In the series of 1,355 cases from the records of the Hospital for

[1] Trans. Am. Ortho. Ass'n, Vol. IX., 1896.
[2] Ibid., Vol. IV., 1891.

Ruptured and Crippled, the attempt was made to locate the origin of the disease by the most prominent spinous process in the tracing. The following are the conclusions.

Cervical.	Dorsal.	Lumbar.	Lumbo-sacral.
1st..... 3	1st 26	1st 94	13
2d..... 3	2d..... 43	2d.....96	
3d.....15	3d..... 42	3d.....64	No Deformity.
4th 20	4th..... 46	4th.....57	Cervical..... 2
5th.....13	5th..... 49	5th 6	Dorsal.....31
6th.....22	6th..... 76	317	Lumbar.....22
7th.....24	7th..... 82		55
100	8th..... 97		
	9th..... 92	Disease in two regions of the spine.	
	10th.....110	16	
	11th..... 71		
	12th.....120		
	854		

Similar statistics are recorded by Julius Dollinger,[1] of Budapesth, of 700 cases of Pott's disease. Of these the situation of the primary disease could be ascertained in 538. Of this number, in 63 the disease was of the cervical, in 321 of the dorsal and in 154 of the lumbar region.

The relative frequency of disease of the different dorsal and lumbar vertebræ, was as follows:

Dorsal.	Lumbar.
1st 6	1st 59
2d. 7	2d.....37
3d.....12	3d.....31
4th.....10	4th.....17
5th.....19	5th.....10
6th.....17	154
7th.....33	
8th.....36	
9th.....36	
10th.....43	
11th.....38	
12th.....64	
321	

The proportionate length of the different sections of the spine at the age of five years is, according to Professor Disse (Skeletlehre, 1896):

Cervical.....	20.2
Dorsal.....	45.6
Lumbar.....	34.2
	100.0

If this be contrasted with the percentage of the cases of disease of each section, it will show that the frequency of the disease in the different regions of the spine does not correspond to the area, as has been suggested, but that it is proportionately much less frequent in the cervical and much more frequent in the dorsal region; a frequency that may be explained by the greater strain to which the middle and lower

[1] Die Behandlung der Tuberculosen Wirbelentzündung. Stuttgart, 1896.

part of the spine is subjected, as well as by the relative proportion of cancellous tissue which offers the opportunity for infection.

Dollinger.		Frank and Gunter.	
Cervical	11.7 per cent.	Cervical	7.6 per cent.
Dorsal	59.6 " "	Dorsal	66.1 " "
Lumbar	28.6 " "	Lumbar	26.2 " "

Prognosis.—The prognosis in tuberculous disease is discussed in Chapter V. : Pott's disease is the most dangerous of all the tuberculous affections of the bones or joints, as would be expected from the relative importance of the structure affected and of the parts lying in contact with it.

It is evident also that the amount of deformity, and its situation, have a direct influence on the prognosis.

In the typical "hump-back" deformity, the contents of the thorax and abdomen are necessarily compressed, the blood-vessels are distorted and the calibre of the aorta is thereby often much diminished. Respiration is made difficult, and the circulation is impeded, so that the heart is usually hypertrophied and valvular insufficiency is not infrequent; thus the vital functions, which are carried on at a disadvantage even under favorable conditions, become impossible under the added strain of unfavorable surroundings, overwork or disease. It is a matter of common observation also that few of those who are markedly deformed reach old age. On the other hand, it may be assumed that slight deformities, or those which do not as directly interfere with the vital functions, exercise but little influence upon the future well-being of the patient.

Although the absolute mortality of Pott's disease cannot be accurately estimated, it may be stated that at least 20 per cent. of all patients die during the progress of the disease and within a few years after its onset, from causes directly or indirectly dependent upon the local lesion. Some of these die from general dissemination of the tuberculous infection and tuberculous meningitis; some from exhaustion following septic infection and long-continued suppuration, or from amyloid degeneration of the internal organs; some, from tuberculosis of the lungs, and many, from intercurrent affections that are fatal because of the devitalizing influence of the disease and its complications.

The prognosis of Pott's disease, in the individual case, is influenced by many considerations. In one instance the family history is good, the surroundings are favorable, the patient is in good condition and the disease is in the early stage; one is then inclined to look upon it as an accident, and hardly considers the possibility of a fatal termination. While in another case, the weakness and under-vitalization of the body are so evident, that the affection of the spine seems but an incident of a general degeneration.

Symptoms.—The most distinctive sign of Pott's disease is deformity. At an early stage of the process there may be but a slight irregularity in the contour of the spine, and if several adjacent vertebral

bodies are affected the projection may be somewhat rounded in outline. But, as compared with other deformities of the spine, that of Pott's disease is characteristically angular, and as its cause is loss of substance, its formation is accompanied by and must have been preceded by the symptoms of bone disease.

Deformity is thus the evidence of a destructive process that may have existed for weeks or months even, and only by its early recognition can the ideal result, the prevention of deformity, be attained. For the spine which, although weak, is still straight may be kept straight, but when the deformity is present, it can be remedied only in part, and it may be difficult even to check its further progress. For as the upper segment of the spine sinks forward and downward, the influences of compression and attrition increase the activity of the local process and aggravate its effects.

Angular deformity has been long considered as the essential sign of Pott's disease, and even now, the fact is not generally recognized that the detection of tuberculous ostitis of the spine in the early stage, is both possible and easy by the same methods that serve for the diagnosis of other affections, not attended by such obvious symptoms as external deformity. It is to such application of the principles of differential diagnosis that attention is especially called.

As the spine is the chief support of the body and as it allows a free mobility that accommodates it to every movement of the trunk and to every motion of the limbs even, it is evident that the symptoms of a destructive ostitis must be pain, weakness, and impairment of normal motion. Motion and support are not, however, the only functions of the spine ; it contains the spinal cord, from which branch the nerves that supply the organs and members of the body. This may be implicated even at an early stage of the affection, and the sudden onset of paralysis may overshadow the symptoms of original disease. Or the tumor of an abscess, one of the common accompaniments of tuberculous disease of bone, may interfere with the functions of important parts lying in the neighborhood of the spine, thus peculiar symptoms, due to this cause, may attract attention before the primary disease is suspected. These are symptoms that may be misleading and it is well, therefore, to consider them apart from those that indicate the primary effect of the disease upon the spine, considered as an elastic support. These direct symptoms usually precede, and always accompany the secondary or complicating symptoms, and upon them the diagnosis depends.

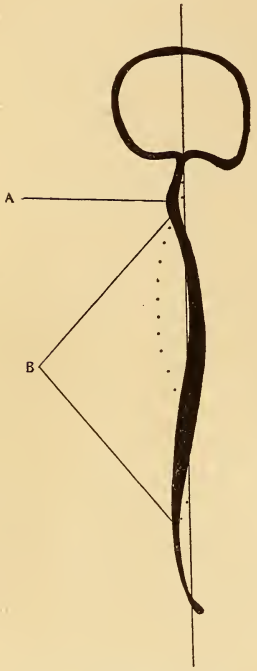
The primary and diagnostic symptoms of Pott's disease may be classified as follows :

(*a*) Pain.
(*b*) Stiffness.
(*c*) Weakness.
(*d*) Awkwardness.
(*e*) Deformity.

(*a*) **Pain.**—At first thought, one might expect the pain of Pott's disease to be localized at the affected vertebræ, and to be accompanied

by sensitiveness to pressure or even by infiltration and swelling of the tissues, but it will be remembered that the bodies of the vertebræ are in the interior of the trunk, practically speaking, as near to its anterior as to its posterior surface (Fig. 9) and that the products of the disease pass downward and forward, rarely backward.

FIG. 5.



A, direct deformity; *B*, compensatory deformity.

Thus sensitiveness to pressure on the projecting spinous processes is unusual, and palpation, except in the cervical region, is of comparatively little diagnostic value.

The pain of Pott's disease is not localized in the back, in the neighborhood of the disease, because the nerve filaments that supply the bodies of the vertebræ are insignificant parts of nerves that are distributed to distant points, to the head, to the legs, to the front and sides of the body and to these parts the pain is referred; thus "earache" or "stomach-ache" or "sciatica" may be symptomatic of Pott's disease of the different regions of the spine.

The pain of Pott's disease is by no means constant, it is induced by jars or by sudden or unguarded movements. It is often worse at night, when after the relaxation of the muscular spasm that has protected the part, the unconscious movements during sleep cause discomfort or pain and the child moans in its sleep, or is restless, and sometimes it wakes with a cry—"night cry."

(*b*) **Impairment of Function or Loss of Normal Mobility—Stiffness.**—Stiffness of the spine, the result of the destructive ostitis, is in part voluntary, in the sense that the patient adapts his movements and attitudes to the disease and pain and thus avoids, if possible, strain and jar—but the essential and characteristic stiffness of Pott's disease is caused by the involuntary muscular tension and contraction of the muscles about the seat of disease. This reflex muscular spasm varies in degree, according to the state of the underlying disease. It may fix the spine or it may be evident only at the extremes of motion, but it is always present, preceding deformity and accompanying it until cure is established; thus it is the most important of the diagnostic symptoms of Pott's disease.

(*c*) **Weakness.**—As the disease affects the most important support of the body, it is a direct as well as an indirect cause of weakness, and the more vulnerable the spine, the more pronounced is this symptom; thus in the young child, whose spine is in great part cartilaginous, evidence of weakness is shown by the "loss of walk," the refusal to stand or the instinctive desire for support, at an early stage of the disease.

(*d*) **Change in Attitude—"Awkwardness."**—This really sums up the

effects of the preceding symptoms, since it is evident that pain, weakness, and rigidity must cause a change in the appearance and in the habitual attitudes of the patient. Such symptomatic attitudes may be almost diagnostic of the disease and of the part of the spine involved.

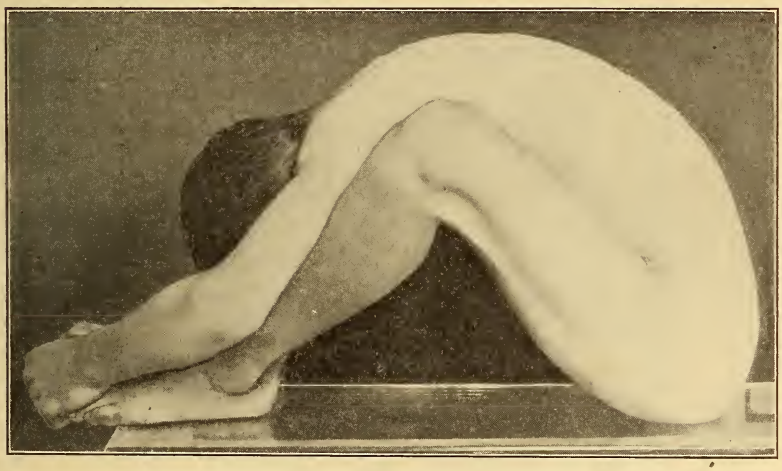
(*e*) **Change in the Contour of the Spine—Deformity.**—The deformities of Pott's disease may be classified as follows:

1. Bone deformity.
2. Muscular deformity.
3. Compensatory deformity.

The characteristic angular projection due to destruction of bone has been described already.

Muscular deformity is the distortion due to muscular spasm or contraction. Of this, the wry neck, symptomatic of cervical disease, and

FIG. 6.



Normal contour and flexibility of the spine.

psoas contraction in the lower region of the spine, are the most familiar examples.

Compensatory deformity signifies the more general effect of the local disease and local distortion, upon the spine as a whole. (Fig. 5.) Thus an angular projection must be balanced by a compensatory incurvation, and lateral distortion in one direction by lateral distortion in another. These deformities are, of course, nearly related, and they are usually combined, although muscular distortion may precede the stage of bone destruction, while the compensatory changes are not immediately apparent. These general and secondary changes in contour may catch the eye before the primary local deformity is detected.

Lateral deviation of the spine is not infrequent; it may be direct distortion at the seat of disease, caused by the destruction of the side of a vertebral body, but more often it is a secondary effect of such

irregular erosion at one or the other extremity of the spine, or the effect of muscular contraction, or it may be due to simple weakness.

Finally, even at a much earlier stage of the disease, there is, almost always, a slight change in the outline of the spine due to local rigidity; thus the spine no longer forms a long regular curve when the body is bent forward, but as one section remains more or less rigid while the other bends, the outline is broken at or near the seat of the disease. (Fig. 7.)

Secondary or Complicating Symptoms.—(*a*) **Abscess.**—This may, by its size or situation, cause peculiar symptoms. In the retro-pharyn-

FIG. 7.

Incipient Pott's Disease. Showing the break in the contour of the spine, of which the normal flexibility is but slightly impaired.

geal space it may interfere with respiration and deglutition. In the thoracic region it might be mistaken for pleurisy or empyæma, and when it forms a tumor in the iliac fossa, it may interfere with locomotion.

(*b*) **Paralysis.**—This is usually a late symptom, but if the disease begins in the center or posterior part of a vertebral body it may implicate the spinal cord before deformity is apparent.

Abscess and paralysis are symptoms that may be explained by Pott's disease, but other than by calling attention to disease of the spine as a possible cause of the complication, they do not aid one in determining the diagnosis; for this reason they are classed as secondary symptoms.

General Symptoms.—By some surgeons, especial stress is laid upon the diagnostic value of a slight but constant elevation of the temperature. This is usually present if the disease is active or when an abscess is approaching the surface, but the positive value of the symptom in early or quiescent cases, is doubtful. One may expect also that a patient suffering from tuberculous disease of the spine will present some evidence of a painful and depressing affection, or some evidence of inherited or acquired weakness, yet it must be remembered that the absence of such general symptoms would not exclude Pott's disease.

The Contour and Flexibility of the Normal Spine.

In the enumeration of the early symptoms of Pott's disease, two have been noted as of especial importance: the impairment of normal mobility and the effect of the disease upon the contour of the spine and upon the attitudes of the patient. Therefore, in the study of the normal spine, the standard with which that suspected of disease must be compared, mobility and contour, at different ages, and under different conditions, should receive especial consideration.

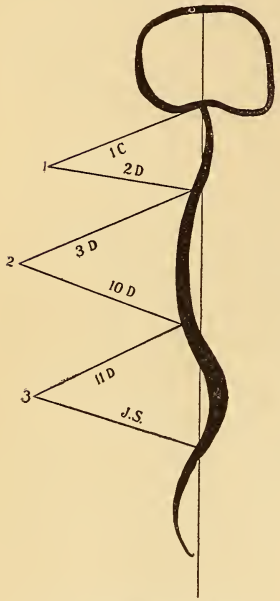
Although the spine as a whole is a flexible column, yet it has a fixed contour; it curves forward in the upper, backward in the middle, and forward again in the lower region. These curves are, in great degree, the effect of the force of gravity and of the action of the muscles in balancing the weight of the body in the upright attitude. In the adult they are practically permanent; in early childhood they can be nearly obliterated by traction in the horizontal position; and in infancy they do not exist. If the newborn infant be placed in the sitting posture the head falls forward and the spine bends in one long backward curve characteristic of weakness. If it be placed on the back and the legs be drawn down from their habitual attitude of semi-flexion, it will be noticed that the range of extension is somewhat limited because of the absence of the lumbar curve and inclination of the pelvis. When the gain in muscular power has been sufficient to enable the infant to raise and control the head the curve of the neck appears. Later when the child stands the erector spinæ muscles hold the body upright against the resistance of the ilio psoas group and of the ligaments of the hip joint; thus the lumbar curve and the inclination of the pelvis result and the normal contour of the spine is established.

If from the odontoid process of the axis of a normal individual in the erect posture a line be dropped to the ground, this perpendicular or weight line, about which the weight of the body is balanced, will indicate the curves of the spine, and divide it into sections that correspond sufficiently well to function. The cervical curve ends at the second dorsal, the thoracic curve at the twelfth dorsal and the lumbar curve at the sacro-vertebral angle. (Fig. 8.)

What has been spoken of as the normal contour of the spine varies considerably in the adult. It is affected by the occupation, and many

other circumstances; of this, the round shoulders of the cobbler or the weaver, the stoop of weakness, of old age and the like are familiar examples: but in childhood, distinct variations from the normal contour almost always have a clearly defined pathological cause. As the normal contour is the effect of the balancing of the body in the upright posture, it is evident that if the outline of one part is permanently changed, compensation for this change must be made in another part. Thus when deformity is well marked, the normal curves of the spine are often completely reversed (Fig. 5), and even at an early stage of the disease, the abnormal contour will often attract attention, long before the characteristic angular projection has become apparent.

Fig. 8.



The divisions of the spine.

Although the spine is a flexible column that is constantly changing in outline with every movement and posture yet the range and character of this motion vary greatly in its different parts. In the cervical and lumbar regions motion is extensive, because of the relatively large proportion of elastic intervertebral substance, because of the direction of the articular surfaces, and because the center of motion is near the middle of the body. Motion is very limited in the thoracic region, because the intervertebral discs are thin, because of the overlapping spinous processes and because it forms a part of the rigid thorax. Where free motion is essential to the habitual attitudes, there disease, which interferes with normal motion, will be earliest apparent, in awkwardness, weakness, and pain, and there, muscular spasm, the chief cause of the rigidity and restraint of normal motion, will be evident on examination.

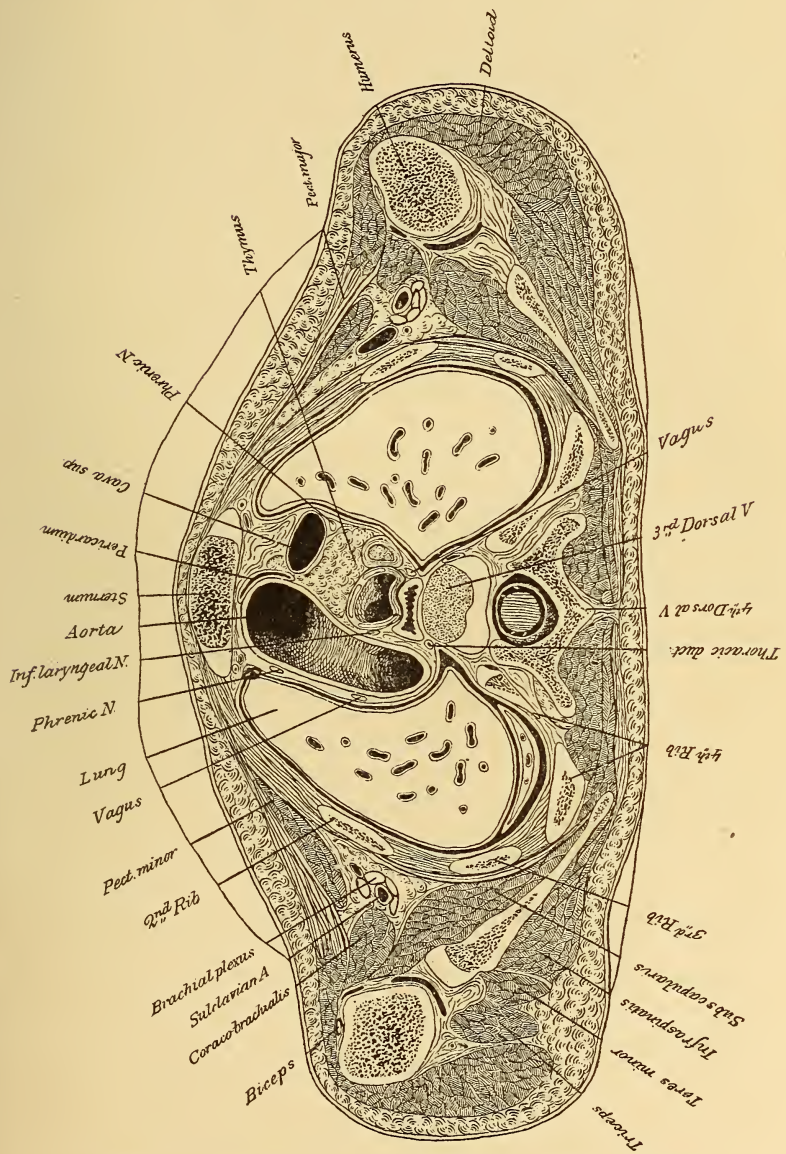
Thus one more often has the opportunity to make an early diagnosis in disease of the lumbar and cervical regions, because in the one the motions necessary in stooping, sitting and standing are constrained, and in the other the neck is stiff, or the head is turned or drawn from the normal line. In the thoracic region, early diagnosis is less often made, because in this section motion is so unimportant that its restraint may escape the attention of the patient or parent. Thus, in considering early diagnosis, and in fact, treatment and prognosis, one must divide the spine into sections.

Divisions of the Spine.

1. The neck part, that allows free motion of the head, ending at the third dorsal vertebra.

2. The rigid thoracic part which includes the third and the tenth dorsal segments.

FIG. 9.



Cross-section of the body of a child at the third dorsal vertebra. (DWIGHT.)

3. The lower portion made up of the two lower dorsal and the lumbar vertebræ, in which the principal movements of the trunk are carried out. One must bear in mind the distribution of the nerves, because the characteristic pain is referred to their terminations, also

the parts in relation to the spine at different levels, that may be implicated in the disease. Thus, remembering that the symptoms of Pott's disease are in general stiffness, weakness, pain and deformity, one will always apply these symptoms to a particular region of the spine, and will picture to himself the effect of such stiffness, weakness and deformity at this or that vertebra; the effect of an abscess in this or that situation, and the area of paralysis that might be caused by pressure on the cord at one or another level.

Landmarks.—The atlas is on a line with the hard palate.

The axis is on a line with the free edge of the upper teeth.

The transverse process of the atlas is just below and in front of the tip of the mastoid process.

The hyoid bone is opposite the fourth cervical vertebra.

The cricoid cartilage is on a line with the sixth cervical vertebra.

The upper margin of the sternum is opposite the disc between the second and third dorsal vertebræ.

The junction of the first and second sections of the sternum is opposite the fourth dorsal vertebra.

The tip of the ensiform cartilage is opposite the lower part of the body of the tenth dorsal vertebra.

The anterior extremity of the first rib is on a line with the fourth rib at the spine, the second with the sixth, the fifth with the ninth, the seventh with the eleventh.

The scapula overlaps the second and the seventh ribs, its lower angle being opposite the center of the eighth dorsal vertebra.

The root of the spine of the scapula, the glenoid cavity, and the interval between the second and third dorsal spines are in the same plane.

The most constant landmark from which to count, is the spinous process of the fourth lumbar vertebra, which is on a line with the highest point of the crest of the ilium. The umbilicus is near the same plane.

The Inclination of the Pelvis.—In the erect attitude the plane of the brim forms an angle of 60 to 65 degrees with the horizon.

The tip of the coccyx is opposite the lower border of the symphysis pubis.

Length of the Spinal Cord.—In the adult the spinal cord terminates at the lower margin of the first lumbar vertebra. At birth, it extends to the third lumbar and its membranes to the second division of the sacrum.

The Intervertebral Discs.—In the adult, the intervertebral discs form 41.9 per cent. of the cervical, 26.4 per cent. of the dorsal, and 44.6 per cent. of the lumbar regions of the spine (Dwight).

The Rational Signs.

The symptoms of Pott's disease vary decidedly, not only with the region of the spine involved, but also with the age and surroundings of the patient. Like other forms of tuberculous disease it is an insidious chronic affection and its early symptoms may fail to attract atten-

tion, because they are irregular or intermittent. The child may cry after over-exertion or injury, but afterward it may appear to be in its usual health, perhaps for days or weeks; but even during this early stage, it will be remembered afterwards, that something was "wrong," that it was fretful and disinclined to play, that it liked to lie on the floor, that it was awkward in its movements, that it was troubled by a cough or indigestion, or by oppression of breathing. One, or many, of such symptoms may have existed for months, but, as a rule, it is not until deformity has made the diagnosis unmistakable, that the child is brought for treatment. It is often after a fall or violent play, that the evidence of pain or weakness can no longer be overlooked, so that injury is likely to occupy a prominent place in the history.

History.—The history of the disease as obtained from the parent is usually indefinite and misleading. Certain points may however be set down as of relative importance.

One will ask if the immediate relatives of the child have suffered from phthisis or other form of tuberculosis, as this might indicate a predisposition to disease, and thus affect the prognosis.

One asks if the child has been robust or the reverse; if recovery from the ordinary ailments of childhood was prompt or tedious, in order that one may judge of the quality of the patient.

One next asks, not "how long has the child been ill?" for this is usually understood to refer to the duration of the more decided symptoms, but "when was the child last perfectly well?" One asks particularly as to the onset of the first symptoms, whether it was sharp and decided, or gradual and ill defined; if the symptoms were preceded by contagious disease. This latter is an important question, because measles, for example, predisposes to tuberculous infection or at least to its local outbreak, and diphtheria is often followed by paralysis or by weakness, that may simulate certain symptoms of Pott's disease. The character of the injury, that almost every patient is supposed to have received, is then investigated. It should be made clear, whether the injury was the direct cause of the symptoms or if it may have simply aggravated, or brought to light the dormant disease or if, as is often the case, there is simply an indefinite remembrance of an injury which has no connection with the symptoms.

To establish injury as the sole and direct cause of symptoms, the patient must have been well at the time of the accident, the symptoms must have followed immediately and have continued since; and finally the symptoms must be of such a nature as to be explained by a definite injury.

By careful questioning one may usually determine whether the symptoms of which the patient complains are acute or chronic. This is of importance because tuberculosis is a chronic disease, one of the few chronic diseases of childhood, although its exacerbations may resemble, in symptoms, those of acute disease or even of injury.

However important a correct history may be, the actual diagnosis depends entirely upon the physical examination.

Physical Signs.

The physical examination begins on the first sight of the patient, when one notes the general condition and the actions and postures; but the ultimate purpose is to compare the appearance and mobility of the spine suspected of disease, with the normal standard.

Voluntary actions and attitudes show the adaptation of the body to the disease, the conscious and unconscious efforts of the patient to guard the weak part from strain, and from motions that cause discomfort and pain. But by inspection, palpation, and by the tests of voluntary and passive motion, one may demonstrate and localize the disease.

The examination must be purposeful. When one asks the patient to pick up a coin from the floor—the popular test for Pott's disease—one employs it to test the mobility of the lower region of the spine, the region in which the motions of stooping and turning the body are carried out; remembering that such movements are often not restrained in the slightest degree by disease in the upper portion of the spine.

Such tests must not only be purposeful, but they must be adapted to the age and intelligence of the patient. The child that refuses to pick up a coin will often gather up its clothing, because it wishes to be dressed again. If it will not stoop, it will usually rise if placed in the recumbent or sitting posture, which is an equally useful test. A child will walk towards its mother, if placed at a distance from her. It will always turn its head towards her, thus voluntary motion of the cervical region may be tested by changing the mother's position, while the child is held by the examiner. Young children, who struggle and resist passive motion if placed on the table, submit quietly when held in the mother's arms.

Various simple and effective tests will suggest themselves to the examiner, who has a definite purpose in view, but much patience may be required in early cases and several examinations may be necessary before the presence or absence of disease can be definitely determined. It is important to remember that in childhood at least, abnormal symptoms always have a cause, therefore a patient should always be kept under observation until the cause is finally discovered.

Of all the early signs of Pott's disease muscular rigidity or reflex muscular spasm is the most important, since it precedes deformity and accompanies it, until cure is finally established. It is a spasm that resists motion in all directions; thus it may be distinguished from the spasm or contraction of certain groups of muscles resulting from irritation or inflammation not connected with the spine. For in such instances motion is limited only in the directions directly opposed by the muscular contraction. True reflex muscular spasm is quite independent of the will, and thus it may be easily distinguished from simple voluntary resistance on the part of the patient.

The muscular rigidity is most marked in the neighborhood of the disease, but it extends to a greater or less distance according to the

acuteness of the local process and the susceptibility of the patient. Even at an early stage the situation of the disease is usually shown by a slight irregularity of the spine in the center of the area, made rigid by muscular spasm, as well as by the change of contour. This change in outline and in flexibility may be demonstrated by bending the patient forward. If the spine forms a long, even, regular curve and if there be no evidence of pain or rigidity, when such an attitude is assumed, Pott's disease is extremely improbable. If, on the other hand, the outline of the curve is broken; if the motion of one section of the spine is restrained by muscular rigidity, disease may be suspected, and if other evidence of tuberculous ostitis is present, the diagnosis may be made with certainty. (Figs. 6 and 7.)

By a careful physical examination one may expect to detect Pott's disease at any stage and to fix upon its location, or at least upon the point suspected of disease. One will then ask oneself if tuberculous disease of the bodies of the vertebræ of this particular region will satisfactorily explain all the symptoms of which the patient complains; if for example, the pain corresponds to the distribution of the nerves, if restraint of function will explain the attitudes of the patient, if the change in contour is significant of a destructive process, and the like.

The principles of differential diagnosis having been outlined they may be applied to the detection of disease as it appears in the different regions of the spine.

The Regional Examination.

1. The Lower Region.—Considering the regions of the spine in the order of liability to disease one begins with the lower section comprising the lumbar and the two lower dorsal vertebræ, that more nearly correspond in shape and function to the lumbar than to the thoracic division.

This is the region of constant and extensive motion, thus the painful rigidity, characteristic of the disease, is often marked long before the stage of bone destruction.

The characteristic attitude of the patient is one of what might be called over-erectness and often there is an increased *hollowness* (lordosis) (Figs. 10 and 12) of the back, so that the prominent abdomen may first attract attention. The *walk* is careful, and a peculiar tip-toeing step with slight inversion of the feet to avoid the jar of striking the heels is often observed; this is however not a peculiarity of disease of this region alone, but is rather an evidence that the spine is sensitive to slight jars. More characteristic of lumbar disease is a peculiar *waddle*, explained in part by the exaggerated lordosis, and in part by the loss of the accommodative, balancing motion of the lumbar spine, as the weight falls alternately on each leg in walking.

The increased lumbar lordosis, so characteristic of the early stage of the disease, is capable of several explanations. It is partly voluntary; as bending the body forward brings pressure upon the diseased vertebral body, so bending it backward relieves this pressure. It is partly

involuntary, caused by the contraction of the large muscular masses on the posterior aspect of the spine; and it is in part compensatory, as the slight psoas contraction which is often present has a tendency to tilt the pelvis forward, necessitating a greater compensatory backward inclination of the body.

As the disease progresses, the lumbar section becomes straighter, and finally it may project backward in the characteristic angular deformity. Yet even after the lordosis has been obliterated the back-

FIG. 10.

Disease of the upper lumbar region before the stage of deformity, showing abnormal lordosis.

FIG. 11.

The same patient (Fig. 10) five years later showing deformity.

ward inclination of the body still continues as a compensation for the change in balance, which the transformation of the forward curve to a posterior deformity has necessitated. (Fig. 11.) Thus over-erectness or backward inclination of the body characterizes the disease of this region from its beginning to its end in uncomplicated cases.

Slight psoas contraction as a part of the general muscular spasm about the point of disease, simply increases the lordosis, but if the contraction is greater, when, for example, an abscess is present which involves the substance of the psoas muscles or forms a painful tumor

in the pelvis, the erect attitude is no longer possible. The legs are drawn toward the body, and the body is inclined forward, to relax the tension. This greater contraction, with the abscess that is usually its cause, is most often limited to one side; thus the patient inclines the body somewhat forward and toward the flexed leg, "favors it" and the resulting limp is usually mistaken for a sign of hip disease.

FIG. 12.

Disease of the lumbar region. First symptom, pain in the knees.

FIG. 13.

Disease of lumbar region with right ilio-psoas abscess and psoas contraction.

Unilateral psoas contraction is, in fact, so often present when the patient is first brought for treatment, that a limp and the accompanying inclination of the body may be considered as characteristic of disease of the lumbar region at a somewhat later stage.

The *location of the pain* depends upon the distribution of the nerves that supply the diseased vertebræ or that pass in its vicinity; it may radiate over the inguinal region or backward to the loins or buttocks

or down the front or back of the legs to the knees. *Painful cramp* in the leg is sometimes a symptom; the thigh is spasmodically drawn toward the body and the patient, seizing it with both hands, shrieks with pain.

Lateral inclination of the body is often present. It is usually a symptom of unilateral psoas contraction and abscess; it may be due also to unilateral contraction of the muscles of the back, or at a later stage, it may indicate collapse or destruction of one side of a vertebral body. In other instances it is not a fixed attitude, but is simply a voluntary adaptation to weakness or pain; thus one may find a large abscess in one pelvic fossa unaccompanied by psoas contraction, while the body is inclined toward the opposite side, the weight being borne habitually on that leg.

FIG. 14.

Lumbar disease. The manner of picking up an object.

The stiffness, weakness and pain, characteristic of disease in this region are exemplified in many ways, for example, the child may be unable to turn in bed; it is slow and awkward in rising in the morning or in changing from an attitude of rest to one of activity. It often prefers to stand rather than to sit because in the latter position more weight is thrown upon the sensitive vertebral bodies. When seated, particularly when riding in a carriage or street car, the patient often sits upon the edge of the seat, the shoulders only touching the back, while the hands rest instinctively on the seat, partially supporting the weight and steadying the spine.

Stooping, a posture that increases the pressure on the diseased vertebral bodies and which necessitates muscular tension and strain in regaining the erect position, is particularly difficult and it is always avoided by the patient if the disease is at all acute. For example when the child is asked to pick up an object from the floor, it either refuses, or it squats on the heels or drops upon the knees (Fig. 14) instead of flexing the spine as in health. Young children, having seized the object on the floor, regain the erect attitude by pushing the body up by the pressure of the hands on the thighs. If the child is placed upon the floor it will, if possible, seize the mother's dress or will crawl to a chair or other object upon which the body may be drawn up by the arms so that the discomfort caused by muscular contraction of the back muscles may be avoided.

After the inspection, and the observation of the motions and attitudes of the patient, the examination of the range of passive motion is made. The patient is placed at full length face downward on a

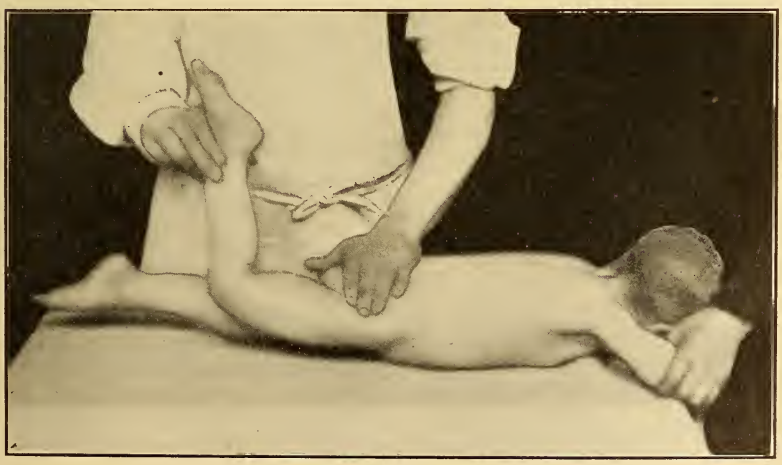
table, and the range of extension, and of lateral motion is tested by lifting the legs and swaying the body gently from side to side. (Fig.

Fig. 15.

Showing the rigidity of the spine before appearance of deformity.

15.) The spine is so flexible in childhood, that rigidity even in the upper dorsal region may be demonstrated by this method, and in test-

Fig. 16.



Test for psoas contraction.

ing the lumbar region, the thorax should be fixed by the hand of the examiner. While the patient remains in this attitude, one should test

for psoas contraction; the pelvis is pressed firmly against the table with one hand, while the leg, held in the line of the body, is gently lifted by the other. (Fig. 16.) As tested in this manner, the normal range of extension should allow the knee to be lifted two or three inches from the table. Slight restriction of extension of both thighs, indicating a slight degree of psoas contraction, is very common in lumbar Pott's disease, but when the restriction is marked, and especially if it be unilateral, a deep abscess may be suspected. Such unilateral psoas contraction may be more clearly demonstrated by placing the child on the back, allowing the legs to hang over the edge of the table, when the unaffected thigh will drop below its fellow. (Fig. 17.)

As a rule, flexion of the lumbar spine is much more restricted in the early stage of the disease than is extension; this rigidity and fixa-

Fig. 17.

A method of demonstrating psoas contraction.

tion may be demonstrated by placing the child on its hands and knees, and lifting it from the floor; when the body, instead of bending over the supporting hands, retains almost its original contour. (Fig. 18.)

As has been stated, even at an early stage of the disease one may often detect a slight fullness about the spinous processes or a slight irregularity in their line, about which the muscular spasm is most marked; this indicates the exact seat of the disease. Deep pressure on the spinous processes at this point will often cause pain, and sometimes greater elasticity at the diseased area may be demonstrated. Except in the hands of an expert, it is, however, a test of comparatively little value; and it may be again mentioned that local pain and local sensitiveness to pressure on the spinous processes, are not characteristic signs of Pott's disease.

Finally, one should always examine for *pelvic abscess*. This may

be suspected when unilateral psoas contraction is present in marked degree, although psoas contraction may be present without abscess and abscess may be unaccompanied by psoas contraction when the substance of the muscle is not involved.

The typical psoas abscess, as pictured and described, is the fluctuating tumor, that suddenly appears on the inner side of the thigh, although it may have been many months in descending to this position from its original site. Demonstrable abscess is present at some time, in at least 50 per cent. of the cases of lumbar disease, and its early detection is a matter of importance, since its subsequent behavior will

FIG. 18.

Disease of the lumbar region before the stage of deformity. A test for rigidity.

often materially influence the treatment. The child is placed on the side, the thigh is flexed and the hand is pressed gently down into the loin and iliac fossa. Sometimes the examination will be made easier by extending the leg and thus bending the spine forward toward the hand. Often, in this manner, one can make out the peculiar sausage-like thickening on one or the other side of the spine, or a larger rounded tumor in the iliac fossa, the presence of which would not otherwise have been suspected.

Diagnosis.—If a careful physical examination were made in all suspicious cases, by one at all familiar with the ordinary symptoms of

Pott's disease, the field for differential diagnosis would be small indeed; but it would appear that such examinations are not often made by the physician who is first consulted. One is often told that the child has been circumcised because of pain about the genitals, or because of weakness of the limbs, supposed to be due to "reflex irritation"; or if the patient be an adult, that he has been treated for sciatica, rheumatism or strain, long after the evidence of Pott's disease, even in the angular kyphosis, would have been apparent on examination.

Pott's disease is most often mistaken for some one of the following affections.

Lumbago—may simulate some of the symptoms of Pott's disease of this region, but it is an acute affection, of sudden onset, usually accompanied by local pain and tenderness of the muscles themselves.

Strain of the Back—is often accompanied by stiffness and pain on motion, but like lumbago, its onset is sudden and its cause is known. The pain is usually localized at the point of injury, it is relieved by rest, and the restriction of motion is, in great degree, voluntary. In Pott's disease the pain is neuralgic; it is often worse at night and the rigidity is due to reflex spasm.

Sciatica.—The pain of sciatica is most often unilateral; it is usually confined to the distributions of this nerve which is often sensitive to pressure throughout its course. The pain of Pott's disease, if it is referred to the legs, is usually bilateral and the nerve trunks are not often sensitive to pressure. In sciatica, movements of the leg that cause tension on the nerve, are often painful, while motion of the spine is free, or but slightly restricted, the reverse of the symptoms of Pott's disease. It is true that lateral deviation and even rigidity of the lumbar spine are sometimes observed in cases of sciatica of long standing, but if the latter symptom is marked, the diagnosis may be regarded as open to question. **Sacro-iliac disease** is far more likely to be mistaken for disease of the hip than of the spine; the pain and sensitiveness are usually localized about the seat of disease and the motions of the spine are not restricted.

Lumbago and sciatica and sacro-iliac disease are extremely uncommon in childhood, and if supposed strains or injuries of the back cause persistent symptoms, the appropriate treatment would be similar to that of Pott's disease; that is to say, fixation and rest of the suspected part, until the cause of the symptoms is made clear.

The attitude, characteristic of Pott's disease of this region, the hollow back, the prominent abdomen combined with the waddling gait, may be simulated by **Bilateral Congenital Dislocation of the Hip**, in which the pelvis is suspended at a point behind its normal position, but in this deformity the gait and attitude have existed since the child began to walk, and are accompanied by the symptoms of bone disease. A similar attitude is sometimes the result of weakness or paralysis of the muscles of the back, as for example in **Progressive Muscular Atrophy**, and again in **Pseudo-hypertrophic Muscular Paralysis.** In this

latter affection there is also a disinclination to stoop, and there may be rigidity of the back, symptoms that, in the early stages, bear a superficial resemblance to Pott's disease, but as there are no other signs of disease of the spine, it can be readily excluded.

When psoas contraction is present in lumbar Pott's disease, the resulting limp, that is often accompanied by pain in the leg, is almost invariably mistaken for a symptom of **Hip Disease.**

It will be remembered that although flexion of the leg caused by psoas contraction is a common symptom of Pott's disease, it is as a rule not an early symptom; thus the history will probably call attention to symptoms referable to the back that have preceded it. Again, the limp of Pott's disease is caused simply by flexion of the leg, a limp that is not, as in joint disease, accompanied by pain on functional use. When therefore, in the physical examination, the tension of the contracted ilio-psoas muscle is relieved by flexing the thigh still further, the other movements of the hip, flexion, rotation and the like, may be shown to be free and unrestrained. Thus hip disease, in which all motions are restrained in equal degree by muscular spasm, may be easily excluded, except perhaps in infancy.

Fig. 19.

Disease of the lower dorsal region. The earliest indication of deformity.

Hip Disease in Infancy.—At this susceptible age there is almost always a sympathetic spasm of the lumbar muscles in acute affections of the hip, and similar spasm of the hip muscles in disease of the lower part of the spine; so that several examinations may be necessary before an exact diagnosis can be made. In such cases the application of a temporary support to the back and leg, such as a spica plaster bandage which will relieve the secondary spasm, is a useful aid in diagnosis.

It has been stated that extension of the thigh is alone restrained in psoas contraction; it will be evident, however, that the presence of a large and painful abscess in the pelvis or thigh would limit motion in

other directions as well; but even in such cases, motion in one or more directions usually remains unrestricted; thus disease within the joint may be excluded.

Secondary Hip Disease.—In Pott's disease of long standing complicated by abscess in which the tissues about the joint are infiltrated, or traversed by discharging sinuses, secondary infection of the hip joint is not an unusual complication. In such cases it is not always easy to decide whether it is or is not present, when the limb is distorted and when motion at the hip is limited by the infiltrated and contracted tissues in its neighborhood.

Pelvic Abscess.—As abscess is such a common complication of Pott's disease, it will be necessary to consider abscesses of other origin, that may occasionally cause symptoms resembling somewhat those of disease of the spine. Such are the *perinephritic abscess*, and more rarely, that of *appendicitis*. They differ from the abscesses of Pott's disease in that they are, as a rule, acute in their onset and are accompanied by constitutional symptoms and by local pain and tenderness. In such cases the motions of the spine may be restrained, but the restraint is in great degree voluntary, quite different from the rigidity due to disease of its substance. It is true that the pelvic abscess of Pott's disease which has become infected may cause constitutional symptoms, but the history of the disability and discomfort that must have preceded the abscess, together with the probable presence of deformity, will make the diagnosis clear. Chronic abscess in the pelvis of other than spinal origin, may be the result of disease of the pelvic bones, or of the sacro-iliac articulations, or of the hip joint. It may be caused by the breaking down of lymphatic glands, or it may have its origin in inflammation about the uterine appendages; and cases of so-called idiopathic inflammation and suppuration of the ilio-psoas muscle have been described. In childhood, chronic abscesses in this locality are almost always tuberculous in character, and are caused by disease of bone, either of the spine or of the pelvis. Disease of the spine can be determined usually by the methods already indicated, but if the abscess is of other origin, its exact cause can be decided in many instances only by an operative exploration. Abscesses of this character, of slow and apparently painless formation may finally cause a swelling in the inguinal region or about the saphenous opening, that in the adult is not infrequently mistaken for *hernia*. In practically all cases, however, the tumor of the abscess may be made out on palpation within the pelvis, while the swelling, although its contents may be in part forced into the abdominal cavity, is very different in feeling from the complete reduction that is usually possible in the ordinary hernia. In addition some sign of the disease of the spine or pelvis, of which the abscess is a result, is almost always present.

Peculiarities of Lumbar Pott's Disease in Infancy.

Attention has been called repeatedly to the great importance of the careful observation of the postures and movements of the patient, to

the change in the contour of the spine and particularly to the abnormal lordosis and peculiar attitude of over-erectness in the early stage of lumbar disease. But the description of attitudes of standing and walking, and the shape of the spine which is the result of the erect posture does not apply to the infant in arms, nor need the spine be divided into contrasting sections for the purpose of differential diagnosis. In Pott's disease of infancy the muscular spasm is more intense and its extent is greater. The child screams when it is moved or when the diapers are changed. There is usually no difficulty in determining the presence of disease from the evidence of rigidity and pain, but, as has been mentioned, it is sometimes difficult to decide whether the lumbar spine or one of the hip joints is involved. Slight irregularity of the spinous processes indicating the position of the destructive process is often evident at an early stage and early abscess is not unusual.

Pott's disease of infancy might be mistaken for *acute rhachitis* or *scurvy* but for the fact that the symptoms of such affections are not limited to the spine but involve to a greater or less degree the limbs and joints, the enlarged epiphyses and other evidences of rhachitis showing that the discomfort and pain are due to a general, not to a local disease.

The Rhachitic Spine.—The deformity of the spine, caused by rhachitis is not infrequently mistaken for the kyphosis of Pott's disease.

It has been stated that a long posterior curvature of the spine characterized the weakness of infancy. It is also characteristic of other forms of weakness and particularly that caused by rhachitis in early childhood. During the subacute stage of general rhachitis the child that has never walked or that has "lost its walk" sits much of the time in its chair, or is held in this position on the mother's arm so that the spine is bent backward and a curvature of the lower thoracic and lumbar region is habitual. Soon a slight projection persists, even when the child is lying down; it usually increases in size and becomes more rigid and permanent, if its exciting cause remains; thus a somewhat rounded and rigid posterior curvature of the dorso-lumbar portion of the spine is formed.

The diagnosis from Pott's disease should be made without difficulty, because the evidence of general rhachitis is always present so that such deformity is almost as much to be expected as would be distortions of the legs were the child walking. If the patient is placed in its habitual sitting posture it will be seen that the deformity is simply an exaggeration of a normal attitude. In this attitude the patient remains contentedly for an indefinite time, whereas if Pott's disease were present, the child would lie on its back or abdomen. Finally, the projection is rounded, not angular, and if the patient be placed in the prone posture the projection may be reduced, in great part, by raising the thighs while gentle pressure is exerted upon the kyphosis; and although the spine is somewhat rigid, and although such extension and pressure may be resisted by the patient, yet there is complete absence of the muscular spasm characteristic of Pott's disease.

It may be stated then that the rhachitic deformity is a rounded curvature of the lower part of the spine. Its cause is weakness and habitual posture. The rigidity depends upon the duration of the deformity. The pain, if the rhachitis be acute, is general and is easily explained by the sensitive condition of the bones and joints. It is true that rhachitis and tuberculous disease of the spine may be combined, but in such rare instances the symptoms of the more serious local disease will make themselves evident as distinct from those of the general weakness.

Recapitulation.—The more characteristic symptoms of disease of the dorso-lumbar region may be summed up as follows:

Increased lordosis or over-erectness and a prominent abdomen; a cautious, constrained or waddling gait; less often, a lateral inclination of the body, or a limp caused by psoas contraction.

Stiffness of the spine, which makes bending or turning the body difficult.

Pain, referred to the back, the inguinal region or down the legs, and in more advanced cases, the characteristic deformity.

Diagnosis.—The attitude may be simulated by congenital dislocation of the hips and by pseudo-hypertrophic muscular paralysis or, more rarely, by progressive muscular atrophy.

The limp may be mistaken for that of hip disease.

The pain and stiffness for sciatica, rheumatism, lumbago or injury.

The abscess is to be distinguished from those from other sources.

In young infants the symptoms may be simulated by hip disease and by acute rhachitis.

Finally the deformity of the subacute form of rhachitis is to be distinguished from that symptomatic of bone destruction.

Disease of the Middle or Thoracic Region of the Spine.

The normal motion of this section of the spine, which includes the third and tenth vertebræ is, as compared with those above and below it, slight; thus, disease of this region may not interfere to a noticeable degree with the general function of the spine.

As this part of the column curves backward, the deformity, often unattended by severe symptoms, is not infrequently mistaken for round shoulders. It seems probable also, because of the normal backward curve, and because of the leverage exerted by the weight of the head and arms, that deformity quickly follows disease. At all events, patients are not often seen before it is present, so that diagnosis is usually evident on inspection of the patient.

The attitudes are not especially significant. If the lower part of this region is involved, and if the disease be at all acute, they are similar to those of disease of the lower region, viz.: erectness, the peculiar, cautious, in-toeing step, and the disinclination to bend the body forward.

If, on the other hand, the upper part is affected, the attitude is

often, particularly in young children, one of weakness; there is a slight forward inclination of the body while the head is tilted backward or is inclined toward one side. A peculiar shrugging, squareness and elevation of the shoulders is often noticed. (Fig. 21.) In many instances the apparent elevation of the shoulders is in reality caused by the deformity, which shortens the neck and lowers the head.

In this connection, it should be mentioned that one of the secondary

FIG. 20.

Pott's disease of the middle dorsal region at an early stage, showing slight increase of the dorsal kyphosis.

FIG. 21.

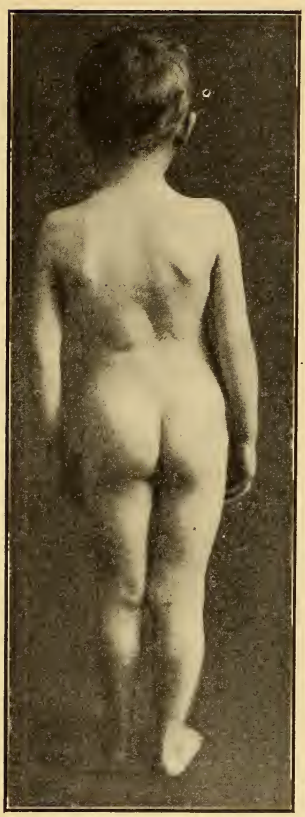
Disease of the upper dorsal region. Characteristic attitude.

effects of the disease, the so-called *pigeon breast*, is, not infrequently, noticed by the parent before the angular deformity of the spine. In the pigeon breast of Pott's disease, the forward inclination of the spine causes a flattening of the upper part of the chest, while the sternum sinks downward and becomes prominent, thus the antero-posterior diameter of the chest is increased, and it is compressed from side to side, so that it resembles very closely the deformity of rhachitis. As

the pigeon breast of Pott's disease is always secondary to the deformity, its cause, of course, becomes apparent on examining the spine.

Of the early symptoms of dorsal disease, pain and labored or "grunting" respiration are the most characteristic. *Pain* referred to the abdomen and to the front and sides of the chest is usually an early and often a constant symptom; thus persistent "stomach-ache" in a child should always lead one to an examination of the spine. A "spasm of pain" is sometimes excited by lateral compression of the chest, as when the child is lifted suddenly by the parent.

FIG. 22.



Marked lateral deviation of the spine with rotation. Deformity at the eighth dorsal vertebra.

Of much greater importance, however, is the *labored or grunting respiration*, which indeed is almost pathognomonic of Pott's disease. This "grunting" is caused by the interference with respiration, more particularly with the normal rhythmical movements of the ribs. The restraint is, in part, due to muscular spasm, and in part to the voluntary efforts of the patient. The inspiration is quick and shallow, in great degree diaphragmatic, and expiration is accompanied by a sigh or grunt. This is apparently caused by a momentary closure of the larynx to resist the escape of air and thus sudden motion of the chest wall. Grunting respiration is, of course, an evidence of the more acute type of disease, but even in mild cases in children it will be noticed when the patient is fatigued, or during play.

An irritating, aimless cough is often a symptom of disease of the upper dorsal region, and spasmodic attacks resembling asthma are not uncommon.

The physical examination will, in most cases, show the characteristic angular kyphosis, and in the exceptional cases, in which deformity is absent, a slight change in contour will be apparent when the patient is bent forward. In place of the long regular curve of the normal spine, a point where two distinct outlines unite will be observed, one of which may be curved while the other is practically straight.

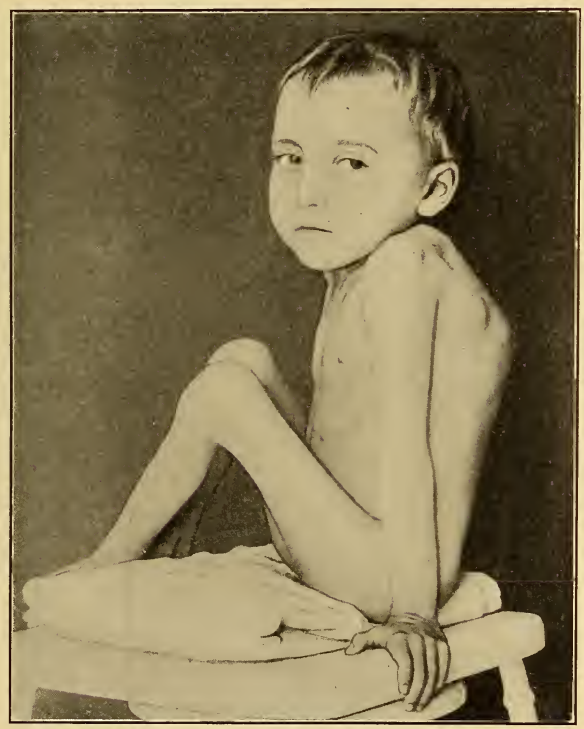
The presence of muscular spasm may be shown by sudden movement of the spine, and it may also be demonstrated, in children, by raising the legs and swaying the body from side to side, as illustrated in the preceding section. (Fig. 15.) The change in the rhythm of respiration has already been mentioned; the restraint does not affect

the motion of all the ribs equally, those that articulate with the diseased vertebræ are often nearly motionless while the movement of those at a distance may approach the normal.

In tracing the neuralgic pain to its origin, the sharp downward inclination of the ribs must be borne in mind; thus, the cause of pain in the "stomach" must be looked for between the shoulder blades.

As in the lumbar region, slight *lateral deviation* of the spine is not uncommon, and it may be accompanied by a slight twist or rotation so that the ribs on one side are more prominent. (Fig. 22.)

FIG. 23.



Double psoas contraction of an extreme degree and paralysis. The arms used as supports.

In disease of this region of the spine the *spinal cord* is more often involved than elsewhere, thus an awkward stumbling gait and finally a "loss of walk" may be the symptoms that first attract attention. This paralysis of Pott's disease and its differential diagnosis are considered elsewhere.

Abscess as a complication, can not be demonstrated by palpation unless it has found an outlet between the ribs, but percussion will often show an area of dullness or flatness, extending from the diseased vertebræ toward the lateral aspect of the chest, due in part, however,

to the inflammatory thickening of the tissues in the neighborhood. In rare instances the abscess may press directly upon the trachea or bronchi and cause spasmodic attacks of dyspnœa resembling asthma.

Diagnosis.—It is hardly necessary to mention the list of affections that may cause pain in the chest or abdomen; it is sufficient to state that such symptoms always require a physical examination. The same statement applies to irregular respiration, to cough and so-called asthma.

Occasionally tuberculous disease of the dorsal spine in adolescence, is not only practically painless, but the resulting deformity is rather rounded than angular, so that it may be mistaken for round shoulders. "ROUND SHOULDERS" is however, as a rule, of longer duration; some exciting cause of postural deformity, in occupation or otherwise, is usually apparent; while the rigidity is less marked than in Pott's disease and pain is absent.

The situation and shape of the rhachitic kyphosis has been described. It should be evident, that a more or less angular projection, in the upper part of the spine could not be rhachitic, and yet because of the absence of pain, this diagnosis is not infrequently made, and as a consequence, the activity of the tuberculous disease may be increased by massage and exercises.

Lateral deviation of the spine as a symptom of disease, could not be mistaken for the ordinary **rotary-lateral curvature**, in which pain and muscular rigidity are absent.

Acute affections within the chest, *pleurisy*, *pneumonia* and *empyema* are sometimes accompanied by lateral deviation of the spine, but the sudden onset, and the constitutional and local symptoms that accompany such affections should make the cause of the deformity and pain evident. It is because these cases are sometimes sent to orthopædic clinics for braces that such causes of deformity seem worthy of mention.

The abscess of Pott's disease in this region, as has been mentioned, causes dullness or flatness on percussion of the chest and within this area friction sounds and râles may be heard.

If the diagnosis of Pott's disease had not been made or if the presence of the abscess had not been determined by the previous physical examination, it might be mistaken, during an acute exacerbation of the disease or constitutional disturbance from other cause, for pleurisy or empyema, and at other times for phthisis. The tuberculous fluid may remain indefinitely in the posterior mediastinum and the area of flatness may extend beyond the axillary line, yet it may give rise to no symptoms.

In all cases then, a careful examination of the chest should be made from time to time in order that the presence or absence of abscess may be recorded.

Recapitulation.—Pott's disease of this region is often insidious in its onset, causing no positive symptoms before the stage of deformity.

Its most characteristic symptoms are pain referred to the front and sides of the body and the grunting respiration.

If the disease is progressive the ordinary symptoms of Pott's disease —weakness and rigidity—are present; in the lower thoracic region, the attitude resembles that of lumbar disease; in the upper, the head is usually tilted somewhat backward and the shoulders appear to be elevated.

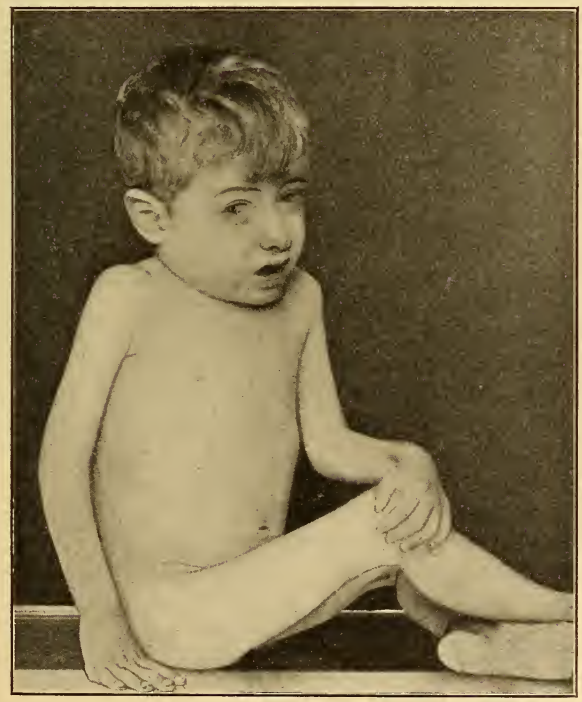
In differential diagnosis, one will consider the significance of pain, the cough or embarrassed respiration and the affections for which abscess or paralysis might be mistaken.

Also round shoulders, rhachitic deformity and lateral deviation of the spine as distinguished from the kyphosis of Pott's disease.

The Upper Region.

The upper region of the spine, which includes the cervical and two of the dorsal vertebræ, corresponds in freedom of motion and in the forward curve, to the lumbar region. For the purpose of study, it

FIG. 24.



Cervical disease with abscess. Characteristic attitude.

must be divided into two parts. Of these, the superior or occipito-axoid section is peculiar, in that it contains no vertebral body or intervertebral cartilage, and in that the movements of the head are carried out in special joints and are controlled by special muscles.

Disease at this point is especially dangerous, because displacement or fracture of the weakened vertebræ may cause sudden death by pressure on the vital centers.

Occipito-axoid disease is comparatively rare, and it is relatively more frequent in adult life than in childhood.

Symptoms.—In a typical case, the symptoms are *neuralgic pain* radiating over the back and sides of the head, following the distribution of the auricular and occipital nerves. *The neck is stiff* and the head may be fixed in the median line, the chin being somewhat depressed, but it is more often tilted to one side, simulating the attitude of torticollis. (Fig. 24.)

The attitude and appearance, when normal movement of the neck is cut off by a painful disease is characteristic; the eyes follow one, or the body is turned, when the attention of the patient is attracted. The patient moves carefully, in order to avoid jar; often the chin is instinctively supported by the hand, and a favorite attitude is one in which the patient sits with the elbows on a table, the hands supporting the head. (Fig. 25.) If the attempt is made to raise the chin, or to rotate the head, the patient seizes the hands of the examiner and, if a child, it screams in apprehension. There is often a slight *bulging and thickening* of the tissues at the seat of disease. The affected vertebræ are usually sensitive to deep pressure, and not infrequently, deep fluctuation in the sub-occipital triangle can be made out.

The atlo-axoid junction lies just behind the posterior wall of the pharynx on a line with the upper teeth and here *abscess* often presents itself, occasionally early in the course of the disease, causing symptoms characteristic of obstruction, such as snoring, change in the quality of the voice, difficulty in swallowing, and sometimes spasmodic attacks of so-called croup. When abscess is present and when the disease is at all acute, the reclining posture sometimes aggravates the symptoms, so that "getting the child to bed" is often a tedious and difficult task.

In certain cases, one may make out the exact location of the disease in the occipito-atloid or the atlo-axoid articulation, but as both joints are to a great extent controlled by the same muscles, this is often impossible when muscular spasm is well marked.

The uppermost joint, that between the atlas and occiput permits the nodding movement of the head, or flexion and extension on the spine; while the atlo-axoid joint permits rotation of the atlas about the axis to the extent of about 30 degrees in either direction. If the disease be in the upper joint the nodding movements will be more restricted than those of rotation and vice versa. The motion of the entire cervical spine is very free so that to make the test one must grasp the neck firmly, in order to restrain motion except in the joint under examination. Because of this freedom of movement, restriction of motion, symptomatic of disease in the upper region, is often overlooked when it is of the sub-acute variety.

The Lower Cervical Region.—The symptoms of disease of the lower cervical section, although similar in character, are often less marked

than those of the upper region. The cervical spine becomes straighter and often a slight backward projection or thickening indicates the position of the disease. The head is usually turned to one side by spasm of the lateral muscles in an attitude of wry neck. (Fig. 26.) The pain is referred to the neck, to the sternal region or down the arms, following the distribution of the brachial plexus.

Fig. 25.

Cervical disease. A characteristic attitude.

In cases of more advanced disease, one's attention may be attracted to the cervical region, because the neck seems short and because the head is tilted backward. The entire back shows a compensatory flattening, yet no deformity is apparent until the occiput is raised and drawn forward, when a shelf-like projection may be felt, at what appears to be the top of the spine, but which is really the angular deformity at the third or fourth vertebra.

This emphasizes the importance of a careful observation of the contour of the spine and the necessity of explaining to oneself every change from the normal that may be noticed.

Disease at the cervico-dorsal junction resembles in its symptoms that of the upper dorsal region. The head is usually tilted backward (Fig. 21) or it may be turned to one side. Disease at this point is often sub-

acute in character, and paralysis from implication of the spinal cord sometimes appears before deformity is apparent.

The seventh cervical or first dorsal spine is often prominent (vertebra prominens) in normal individuals and it may be mistaken for the deformity of disease, especially when pain about this point is a symptom, as in hysterical or hyperæsthetic persons. If such projection is symptomatic of disease there is almost always a slight compensatory flattening of the spine below the point and a certain amount of rigidity of the surrounding muscles.

Diagnosis.—As stiffness and distortion of the neck are the most prominent symptoms of disease of this region it will be necessary to consider first, the forms of *Torticollis* for which it might be mistaken. In typical torticollis or wry neck, the distortion of the head is caused, almost invariably, by contraction of the muscles supplied by the spinal accessory nerve, the sterno-mastoid and trapezius, so that the chin is slightly elevated and turned away from the contracted muscle.

FIG. 26.

Disease of the middle cervical region at an early stage.

Congenital Torticollis which has existed from birth is not accompanied by pain and it could hardly be mistaken for a symptom of disease.

Acute rheumatic Torticollis, "stiff neck," is sufficiently common to be familiar in its characteristics. It is of sudden onset, "in a single night"; the affected muscles are sensitive to pressure; the course of the affection is short, and it is of comparative insignificance.

A more persistent form of acute **torticollis,** accompanied by greater muscular spasm and by local tenderness, sometimes follows of enlarged or suppurating cervical glands; it may follow "earache," tonsilitis or sore throat or any form of irritation about the pharynx. This form of wry neck is not only more painful, but it may last indefinitely, and permanent deformity may result. The onset is usually sudden; the pain and tenderness are local, and are confined, as a rule, to the contracted part. The sterno-mastoid and trapezius muscles are most often involved, thus the wry neck is typical. If the tension be relaxed by inclining the head toward the contracted muscle, motion of the spine itself will be found to be free and painless, but if traction be made on the contracted muscle, it causes discomfort, thus it is usually resisted by the patient.

In disease of the occipito-axoid region, the distortion of the head is, by no means, typical of sterno-mastoid contraction; it may be tilted up or down or laterally to an exaggerated degree. In other words,

the wry neck of Pott's disease is an irregular distortion, not dependent on the contraction of a particular muscle or muscular group. "In torticollis the chin is turned away from the contracted muscle while in Pott's disease it is turned toward the contracted muscle." This is an axiomatic expression of the fact that the distortion of the head symptomatic of atlo-axoid disease, depends, in great degree, upon the spasm of the small muscles that directly control these joints, the recti and obliqui and not directly upon the contraction of the sterno-mastoid muscle, as in the ordinary form of wry neck. Again the contraction, symptomatic of Pott's disease, of this or other regions, is the result of muscular spasm, a muscular spasm that fixes the head and prevents painful motion. If the head be grasped firmly by the hands and if gentle traction be made, the muscular spasm relaxes and the patient experiences a sensation of comfort, while if similar traction is made upon the contracted muscles of simple wry neck, the pain is increased and the patient protests.

In disease of the middle cervical region, however, the distortion due to the reflex muscular spasm, is similar to that of simple torticollis, and it is sometimes difficult to distinguish one from the other, particularly if the latter is caused by the irritation of inflamed or suppurating glands. For, in such cases, there is usually much sensitiveness to manipulation and a more or less general muscular spasm, so that diagnosis may be impossible, until apparatus has been applied to rest the part, and to correct the deformity.

It has been stated that the head was often tilted backward to compensate for deformity in the middle cervical region. It is also, in some instances, drawn backward by spasm of the posterior muscles. Such a case might be mistaken for **cervical opisthotonos**, in which the head is held in an over-extended position, as is sometimes seen in young infants suffering from exhausting diseases, basilar meningitis and the like. In such conditions, however, the characteristic symptoms of Pott's disease are, of course, absent.

The opposite attitude, viz., a forward droop of the head due to weakness of the trapezii muscles, is not uncommon as a sequence of **diphtheria** or other forms of contagious disease. This droop may be accompanied also by spasm of one of the sterno-mastoid muscles and by pain. In such cases, the history of the preceding affection, the weakness or paralysis of other parts, as of the soft palate, the muscles of accommodation of the eye and the like, together with the general bodily weakness that the patients often present, should make the diagnosis clear.

Injury to the upper segment of the spine, a sprain, contusion, or fracture unless efficiently treated, may cause symptoms resembling very closely those of tuberculous disease; for example, the pain often radiates over the back of the head, and there may be rigidity and deformity of the neck, and even infiltration and local tenderness about the injured part. Such cases, when seen several weeks or months after the accident, are puzzling, because one may be in doubt whether the symp-

toms were caused by a simple injury or whether tuberculous infection may have followed or preceded it. In such cases a positive diagnosis cannot be made until the effect of rest and protection has been observed, that is to say, suspicious cases should be treated as one would treat actual disease. If the case is simply one of injury, recovery will be rapid and complete, while if disease be present, the symptoms only, will be relieved.

The occipito-axoid articulation may be involved in **acute articular rheumatism**, or in chronic **rheumatoid arthritis**, when the diagnosis is of course easily made, but occasionally the joints at the upper extremity of the spine may be the seat of what appears to be an infectious arthritis, in which the symptoms are of sudden onset and are sometimes combined with fever and constitutional disturbance, and in which no other joint is involved. The sudden onset and the rapid recovery are the diagnostic points.

Abscess in the cervical region is a secondary symptom, and although it may first attract attention to disease by the change in the voice or the difficulty in breathing or swallowing, yet it is always accompanied by some of the characteristic signs of Pott's disease.

Whenever the diagnosis of cervical disease is made, one should examine the throat, and whenever a chronic retro-pharyngeal abscess is present one should look for the symptoms of Pott's disease.

The diagnosis of the retro-pharyngeal abscess can be made only by inspection and palpation; therefore, one need only mention the fact, that symptoms of obstruction in the throat, similar to those of abscess, may be caused by adenoid growths and enlarged tonsils.

Retro-pharyngeal abscess is by no means always symptomatic of Pott's disease. It may be acute, as one of the sequelæ of contagious disease or as a complication of pharyngitis. It is then rapid in its onset and is not accompanied by the symptoms of Pott's disease.

Recapitulation.

If the disease is of the upper or occipito-axoid region the head is usually fixed in an attitude of deformity, which is sometimes slight and sometimes extreme.

In the middle region, the attitude more often resembles that of ordinary torticollis. In the lower region, there is often no marked spasm of muscles, but the head hangs backward or toward one shoulder.

The contour of the cervical spine changes as the disease progresses, the normal anterior curvature is obliterated, thus the head is pushed forward, while the dorsal section of the spine becomes flat or even incurvated in compensation. The seat of the disease is often shown by an area of thickening or local tenderness to deep pressure.

Disease of the joints of the upper or occipito-axoid section is often acute in onset, sometimes a form of synovial tuberculosis, and abscess is a very frequent complication.

Differential diagnosis of disease in this region will include the consideration of the various forms of wry neck, cervical opisthotonos, diphtheritic paralysis, and injury. Retro-pharyngeal abscess must be distinguished from that not connected with the bone, and from other forms of obstruction in the throat.

Diagnosis in General.

Weakness and the so-called "loss of walk" are well-known symptoms of Pott's disease, and on this account children suffering from different forms of weakness or paralysis are often sent to orthopædic clinics for the treatment of "spine disease."

Certain forms of paralysis bear a superficial resemblance to some of the symptoms of Pott's disease, for example **pseudohypertrophic muscular paralysis** to the attitude caused by disease of the lumbar region and **diphtheritic paralysis** to that of the dorsal region. **Spastic paralysis**, of cerebral origin, resembles somewhat the paralysis of Pott's disease, but it may be differentiated by the absence of pain, by the history and by what is apparent in most cases, the mental impairment.

The contractions combined with the weakness and pain that sometimes follow **cerebro-spinal meningitis** may be mistaken for the symptoms of bone disease, but are as a rule readily explained by the history of the case.

Forms of organic disease of the spine, other than tuberculous, as, for example, malignant disease, syphilis and the like, are described in Chapter II.

The list of affections that has been considered in the differential diagnosis, is a long one, but it has been made up from actual experience. Most mistakes in diagnosis may be explained by carelessness or ignorance, or because of insufficient opportunity for examination; but in the earliest stages of the disease, repeated examinations, time for observation and even tentative treatment may be necessary before the diagnosis is confirmed.

The Roentgen Ray Photography as a Means of Diagnosis.—The Roentgen ray is of value as a means of determining the exact extent of the disease. If the negative is well defined, the diseased vertebræ are seen to be irregular in outline or they may be lost in a peculiar blur. By counting from above and below the exact extent of the disease may be made out, but inferences as to its character and quality must be made from the rational and physical signs.

The Record of the Case.

The history and the result of the examination of the patient should be recorded somewhat in the following order.

1. The family and the personal history.
2. The story of the disease with especial reference to its mode of onset, its probable duration, to the noticeable symptoms and to previous treatment, if any.

3. The physical examination. This should include the general condition of the patient; the height and weight; the attitude; the character of the disease, whether acute or otherwise, as shown by the muscular spasm and pain on motion; the presence of abscess as a complication, or paralysis; and finally, the position and extent of the disease. This is best shown by a tracing, made by means of a strip of lead or pure tin of such thickness that it may be readily moulded on the spine and yet hold its shape when removed. Young's device, consisting of movable pins set in a frame, is a serviceable appliance for this purpose.

The tracing should be of the entire spine, made while the patient lies extended in the prone position, and the exact location of the most prominent spinous processes should be marked upon it. In determining the position of the disease it is well to count the spinous processes from below upward, beginning with that of the fourth lumbar vertebra, which lies on a line drawn between the highest points of the iliac crests. There are other landmarks that are approximately correct. Sometimes the last rib may be traced to its origin, the scapula covers the second and seventh ribs, the root of the spine of the scapula and the middle point of the glenoid cavity being on a line with the third, and its inferior angle opposite the tip of the seventh dorsal spinous process. The upper margin of the sternum is opposite the interval between the second and third dorsal vertebræ. The vertebra prominens can often be distinguished, as may the spinous process of the axis.

Such landmarks are, of course, somewhat displaced in deformity, but they are always sufficiently correct to check errors in counting the spinous processes.

The history furnishes a foundation on which treatment is conducted and from which its results are ascertained. The study of final results has become of great importance in orthopædic surgery, and on this account the record should present the condition of the patient when treatment is begun, in a form that may be readily understood, not only by its writer when details have been forgotten, but by anyone who may in after years consult it. To this history notes during the course of the disease on its complications and incidents and on the changes in the treatment, together with tracings of the spine, are added at regular intervals until the patient is cured.

Treatment.

The general treatment of tuberculous disease is considered in Chapter V. Pott's disease is the most important of the tuberculous affections of the bones, and the importance of proper surroundings, proper food, sunlight, and, within certain limits, exercise in the open air, can hardly be exaggerated.

The General Principles of Mechanical Treatment.—Under normal conditions the weight of the head and of the thoracic and abdominal

organs tends to bend the spine forward and downward, a tendency that is resisted by the action of the muscles of the back. If the resistance is weakened, as in Pott's disease by the direct destruction of the weight-bearing portion of the spine, this tendency toward deformity is, of course, greatly increased. Thus the pressure and strain of the superincumbent weight upon the weakened part that the upright posture entails, are, from the mechanical standpoint, the most important factors in the production of deformity.

When the body is bent forward, as in the stooping posture, the intervertebral discs are compressed and the pressure upon the vertebral bodies is increased; so, on the other hand, when the body is held erect or is bent backward, this pressure is lessened, and a part of the weight is transferred to the articular processes and to the posterior parts of the column. In fact, specimens show that the continuity of the spine may be preserved, and that weight may be supported even when a vertebral body has been practically destroyed.

The object of a brace or other support used in the treatment of Pott's disease is to hold the spine in this extended position, so that pressure on the diseased vertebræ may be removed. One aims to splint the spine as, for example, one would splint a broken back, in order to relieve the symptoms of discomfort and pain, so depressing to the patient, and to secure the rest that is essential to repair.

The effectiveness of a particular splint or support, when applied to a broken leg or to a diseased spine, depends upon the area that it covers on either side of the part to be supported and upon the accuracy of its adjustment, as well as upon the damage that the part has already sustained, and the strain to which it still may be subjected.

It must be evident that the body because of its size, shape and contents is not suitable for the accurate adjustment of support, and it is apparent also that the mechanical conditions are more unfavorable in some parts than in others. For example, in the middle of the back the splint is likely to be effective, because its two extremities, attached to the pelvis and to the shoulders, are equidistant from the point to be supported.

These conditions are reversed in disease of the upper thoracic region, because the weight of the head and of the arms tends to increase the deformity and because of the insufficient leverage that can be secured for the supporting appliance. The pelvis is the base of support for all forms of splints, and if it be smaller than the abdomen, as in infancy, the adjustment of efficient support is very difficult.

Although, in actual practice, the treatment of Pott's disease is influenced by many circumstances, by the age of the patient, the situation of the disease, the duration of the deformity and the like, yet the relative efficiency of braces or other appliances may be decided on purely mechanical grounds. Thus, as the ultimate deformity of Pott's disease is, in great degree, caused by the *force of gravity acting on a weakened spine*, the most effective treatment must be fixation in the horizontal position, since only by this means can the strain of use, and

the pressure of the superincumbent weight be removed completely; and relief from jars and injury, that favor the extension of the disease, be assured.

Horizontal Fixation.—Apparatus for this treatment must be quite independent of the bed on which it may be placed, and of such appliances several forms may be employed.

The reclinationgypsbettes of Lorenz[1] is simply a posterior case of plaster of Paris enclosing the head and body.

The Phelps bed is somewhat similar. A thin board is cut in the outline of the child's body and extended legs. It is padded with cotton wadding and covered with cotton cloth; the patient is then placed upon it, and plaster bandages are applied to enclose the body and the legs. Later the front is cut away, so that the patient may be removed from the bed, for an occasional bath and change of clothing.[2]

The wire cuirasse has been popularized by Sayre;[3] it is an effective appliance although somewhat cumbersome and expensive.

A more effective and more convenient form of support is the Bradford frame or stretcher. This is a rectangular frame of ordinary galvanized gas pipe, or better, of the lighter steel tubing. It should be a few inches longer and slightly wider than the patient's body. Over the frame, a cover of strong canvas is drawn tightly by means of corset lacings or straps on its under surface. The center of the cover should be protected by a strip of rubber cloth, as will be found to be

FIG. 27.

Bradford's bed-frame. (BRADFORD AND LOVETT.)

most convenient in the treatment of young children, who wear diapers; or an interval may be left for the use of the bed pan, as in the illustration (Fig. 27); or preferably the cover may be made in three parts, of which the middle section may be removed when necessary, so that the buttocks may not sag into the opening, and thus make the support for the spine less efficient. Several sets of canvas covers may be provided, to allow for frequent washing; small linen draw sheets may be used to protect them, and a folded sheet or thin hair mattress may be inserted between the layers of the canvas cover, if the straps or lacings

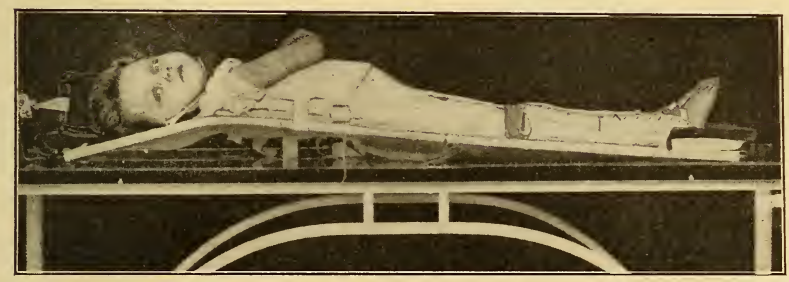
[1] Vide Hoffa, Lehrbuch der Orthopädischen Chir., p. 313.
[2] The Phelps plaster-of-Paris bed, Trans. Am. Ortho. Ass'n, Vol. IV., 1891, p. 83.
[3] La gouttière de Bonnet. Rédard, Chir. Orthopèdique, p. 243.

cause discomfort. These refinements are, however, not essential in hospital practice.

As has been stated, the position of over-extension is that most favorable to repair, and this attitude can be assured by bending the bars upward from time to time as the deformity recedes, and as the patient becomes accustomed to the apparatus. The spinous processes should be protected by thick pads extending on either side of the spine at the seat of disease. These are sewed to the cover and when properly adjusted they assure better support and fixation.

The method of attaching the patient to the frame varies somewhat according to the situation and character of the disease. In ordinary cases a canvas apron, similar to that used with the back brace (Fig. 35), is applied and is buckled to the sides of the frame, while the shoulders are held down by straps crossing the chest, or by axillary straps connected by a chest band. If still more effective fixation is desired, as in disease of the upper dorsal region, the anterior shoulder brace, as

FIG. 28.



The modified stretcher splint, showing over-extension of the spine, with traction for the head and limbs as applied for Pott's paraplegia.

used with the back brace (Fig. 33), may be attached to the axillary straps. In disease of the upper and middle regions of the spine restraint of the legs is not necessary, but in lumbar disease a broad swathe should be passed across the thighs.

In disease of the upper region of the spine a certain amount of traction is desirable to aid in the reduction of deformity and to prevent the patient from raising the head. This traction is usually applied by means of the halter as used with the jury mast. The straps are attached to a crossbar at the upper extremity of the frame and traction may be made by simply tightening them, or if the upper part of the frame is somewhat elevated the weight of the patient's body makes the proper extension. This position has the advantage, also, of allowing the patient a better opportunity to see what is going on about him.

In disease of the middle cervical region traction is usually of service, and fixation of the head is always indicated in addition when the occipito-axoid region is involved, either by sand bags on either side or, preferably, by some form of metal brace.

In the treatment by horizontal fixation, the child, wearing only the underclothing, is attached to the frame, and after the apparatus has been properly adjusted, he is never allowed to sit up or to turn the body or to raise the head until this form of treatment has been discontinued. Children quickly accustom themselves to a restraint that so effectually relieves the symptoms of weakness and pain.

Once a day, as a rule, the patient is removed from the support in the following manner: The frame is placed upon a bed and, the straps having been loosened, the child is turned from the frame face downward upon the bed by two persons, one of whom supports the head and shoulders and the other the pelvis, in order that the back may be held rigid; the shirt which opens in front is then removed, the back is rubbed gently with alcohol and powdered; irritated points are carefully protected and bed sores are prevented by padding to remove pressure. Usually no trouble whatever is to be anticipated on this score. The frame bed is carefully prepared, the draw sheet is changed and the canvas cover is tightened if necessary. It is of course a great convenience to have two frames so that an immediate change may be made from one to the other.

Greater fixation of the spine may be desirable in cases of more acute disease. This may be attained by the use of a light back brace, or a plaster jacket, in connection with the frame. Such support should not be applied however until the recession of deformity, which is to be expected under treatment by the horizontal fixation, has been obtained.

As has been stated the child is placed upon the frame wearing nothing but the underclothing. The outer garments are made large enough to cover both the body and the frame so that a change can be made without disturbing the apparatus. Thus protected, the child may pass the entire day in the open air. It may be carried in the nurse's arms or a carriage may be arranged for it. In colder weather the patient may be enclosed in a sleeping bag of blanket or skin.

Of the conditions that have been mentioned as favorable to the cure of tuberculous disease, but one is lacking in the treatment by horizontal fixation; this is exercise. Exercise may be in part replaced by massage of the arms and legs, and in any event, beneficial exercise is usually out of the question during the phases of the disease for which treatment by the frame is indicated.

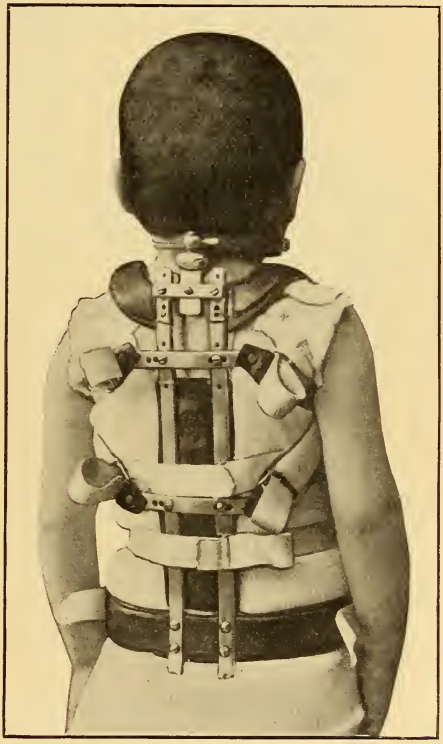
Its disadvantages, when properly employed, are in great degree imaginary, while its positive effects in checking the progress of deformity and in relieving the symptoms of the disease will be apparent at once. The indications for treatment by this method will be considered after the description of the other forms of support.

However efficacious the horizontal fixation apparatus may be, it is incomplete in itself since it must be supplemented by some form or support when the erect posture is again assumed. Such supports are either metallic braces applied directly to the spine or a form of jacket that surrounds the body; each removes a part of the superincumbent

weight from the seat of disease by holding the body in the extended position and each splints the weakened spine more or less effectively.

The Back Brace.—The spinal brace, or spinal assistant, as the original appliance of Dr. C. F. Taylor was called, consists essentially of two steel bars that are applied on either side of the spinous processes from the top to the bottom of the spine. At the seat of disease pads are placed to provide for greater pressure and fixation, and thus, a fulcrum over which the spine may be straightened or held erect, when the two extremities of the brace are firmly attached to the pelvis and to the shoulders. The attachment at the lower end is made by means of a pelvic band of sheet steel (gauge 18) from one and a-half to two inches in width, long enough to reach from one iliac spine to the other; it is placed as low as possible on the pelvis, in other words, just above the upper extremities of the trochanters. To this the uprights are firmly attached at an interval of from one and a-quarter to one and three-quarter inches from one another, so that the spinous processes may pass between them, while pressure is made on the lateral masses of the vertebræ. The uprights are made of varying strength, according to the age of the patient, usually about one-half an inch in width (of gauge 8 to 12) and of such quality of steel, that although unyielding to the strain of use, it may be readily bent by wrenches, and thus accurately adjusted to the back. The uprights reach to the root of the neck, or to about the level of the second dorsal vertebra; from this point two short arms of metal project forward and outward, on either side of the neck, reaching to about the middle of the clavicles. To these, padded shoulder-straps are attached, which pass through the axillæ to a crossbar on the back brace; thus downward pressure on the shoulders is avoided and increased leverage is assured. (Fig. 29.)

Fig. 29.



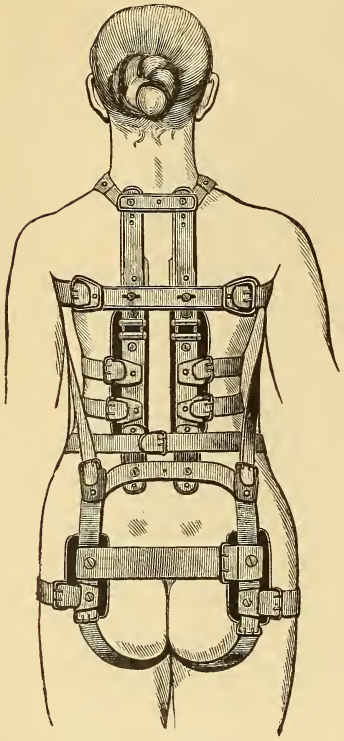
The Taylor brace and head support applied for disease of the upper dorsal region.

Opposite the point of disease, two strips of thin steel about three inches in length are fixed; these are slightly wider than the uprights

and are perforated for the attachment of the pressure pads. They may be made of layers of canton flannel or felt, or unyielding material, such as leather or hard rubber, may be used instead. The pads should project from a quarter to a half inch in front of the uprights, in order that firm and constant pressure, to the extent that the skin will tolerate, may be made at the seat of disease.

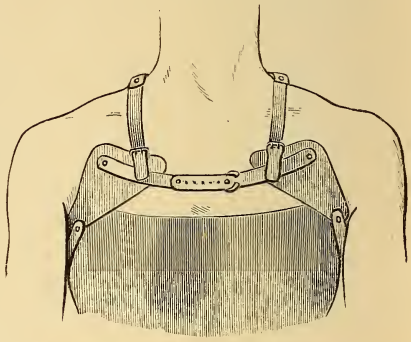
In measuring for this brace the patient is placed in the prone posture and a tracing of the outline of the back is made by means of the lead tape. This outline may be cut in cardboard and fitted to the back; in fact, if the mechanic is unfamiliar with the work, each part of the brace, uprights, pelvic band, etc., may be cut in cardboard and attached to one another to serve as a model. Before the brace is finished it should be applied to the back and should be carefully adjusted by means of wrenches. The pelvic band is then padded and the parts that come in direct contact with the skin are usually covered with leather,

FIG. 30.



The Taylor back brace. (H. L. TAYLOR.)

FIG. 31.



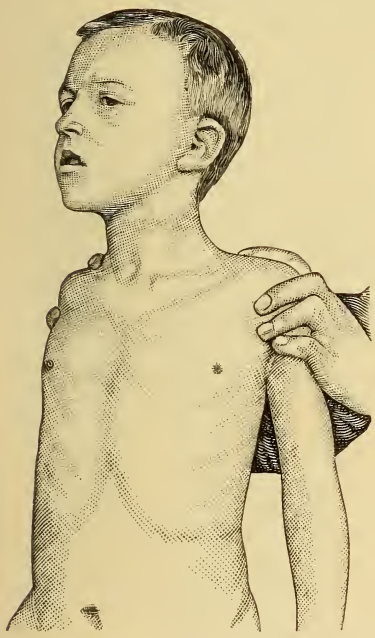
The Taylor chest piece. Two triangular pads of hard rubber connected by a bar.

or, in the treatment of young children, with rubber plaster and canton flannel to prevent rusting.

If the brace is applied before the stage of deformity, it should follow the exact shape of the spine, but if deformity is already present, particularly in disease of the thoracic region, it should be made somewhat straighter, in order to permit a gradual correction of the compensatory lordosis in the lumbar region, and for increased leverage above the deformity. As has been stated, a certain amount of recession of deformity can be obtained by rest in the horizontal position, and if practicable this improved contour should be attained before the brace is applied. The apparatus is held in place by an "apron"

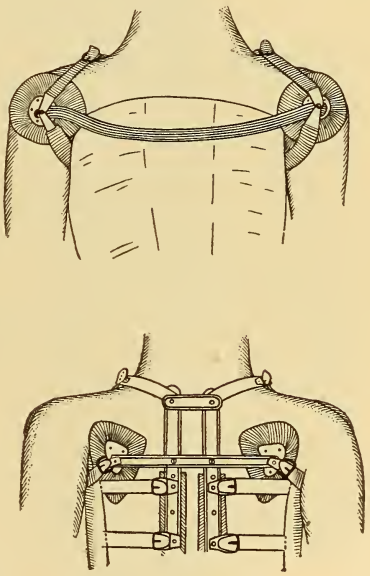
(Fig. 35) which covers the chest and abdomen, to which straps are attached. Ordinarily this is made of strong linen or cotton cloth, but a canvas front shaped accurately to the body and strengthened with whale bone, is a much more comfortable and efficient support. In applying the brace the pelvic band is first attached to the apron, then the straps in order, from below upward, and finally the shoulder straps. Each strap is tightened until the brace is firmly fixed in proper position. When a brace is properly applied and properly fitted, it holds its place by friction, but in certain cases, when the disease is low in the back, it is sometimes of advantage to apply perineal straps to hold

FIG. 32.



Backward traction on the shoulders fixes the upper dorsal region.

FIG. 33.



The anterior shoulder brace and its attachment.

the pelvic band firmly in its place. (Fig. 30.) At first, the brace is removed once a day in order to wash and powder the back, the same care being observed in moving the child as in the treatment by the frame, but when the back has become accustomed to the pressure, the brace should be removed only at infrequent intervals, and thus if desirable, only under the supervision of the surgeon.

This description indicates the essential qualities of the back brace. It has been modified in various ways; for example, Dr. Taylor long since discarded the straight pelvic band in favor of one of a ∪ shape. (Fig. 30.) This makes the brace somewhat lighter and relieves the sacrum from pressure, but it does not add to its effectiveness. The efficiency may be increased however by improving the attachment at

its upper extremity. Taylor has done this by placing two triangular pads against the chest as shown in the diagram. (Fig. 31.) Schapps uses in place of the apron an anterior frame of metal, counter pressure on the chest being provided by means of a broad pad of perforated sole leather. At the lower part a band of metal crosses the body and pressure is made directly on the anterior borders of the pelvic bones.

Each method is an improvement on the simple shoulder straps of the

FIG. 34.

The Taylor back brace and head support combined with the Whitman anterior support.

original brace, but neither provides the quality of support and fixation that is required, when the disease is of the upper and middle segment of the thoracic region. In such cases the upper part of the chest is flattened, the inclination of the ribs is increased and the shoulders incline forward, carrying with them the scapulæ. Thus the weight and the strain of the motion and use of the arms tend to increase the deformity.

In health, direct forward or reaching movements of the arms are always accompanied by an increase in the posterior curvature of the

dorsal spine. On the other hand if the shoulders are drawn backward and held in this attitude, the curvature of the spine is lessened and the chest is elevated and expanded. (Fig. 32.)

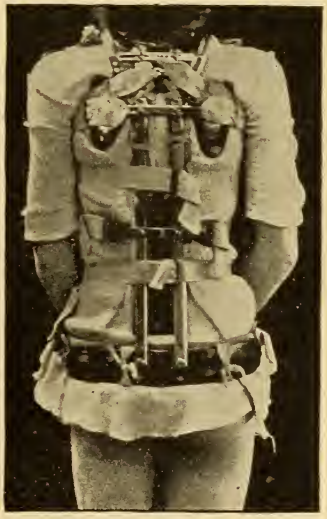
In the treatment of disease of the upper dorsal region it should be the aim, in the application of a brace, to follow this indication and to apply pressure directly upon the extremity of the shoulders to assure the greatest possible fixation of the spine and to restrain the movements of the arms, that tend to increase the deformity.

The accompanying diagrams (Fig. 33) show how such support may be applied. Two saucer-shaped plates of hard rubber or padded metal

Fig. 35.

The anterior shoulder brace.

Fig. 36.



The scapular pads.

cover the heads of the humeri and are joined by a rigid bar of steel which passes across but does not touch the chest. On the back brace are placed two triangular pads of similar construction which cover and press upon the scapulæ. These pads are however not essential and are often omitted. The back brace is applied, the shoulders are then drawn backwards and the shoulder cups are firmly attached by straps to the neck bars of the brace above and below by axillary bands in the usual manner. By this means the thorax is elevated and the spine is more effectively fixed, while direct movement of the arms forward is made impossible. It would seem that such restraint would be irksome to the patient, but in an extended use of the apparatus this has never been complained of. In many instances, even when the disease is as low as the tenth dorsal vertebra it may be used with advantage but it

is especially indicated when the disease is in the neighborhood of the seventh dorsal vertebra. In connection with the shoulder brace it is usually advisable to apply a support beneath the chin to prevent the forward inclination of the neck and to tilt the head somewhat backward. A very simple and inoffensive support of this character is a loop of steel surrounding the neck and attached by screws to a back bar on the brace. (Fig. 37.) If a more efficient brace is required, as when the disease is of the upper dorsal or cervical regions, the Taylor head support should be used. This is an oval ring of steel which may be clasped about the neck by means of a lateral hinge. On the front a cup of hard rubber supports the chin and behind the ring fits upon an upright pivot, that may be raised or lowered upon a cross-bar on the upper part of the brace; free lateral motion is allowed or it may be checked by means of a screw. (Figs. 34 and 39.)

FIG. 37.

The loop head support.

FIG. 38.

Disease of the middle cervical region, showing deformity and attitude. This patient had been paralyzed for one year before treatment was begun. (See Fig. 39.)

If absolute fixation of the head is indicated as in disease at or near the occipito-axoid region two steel uprights may be attached to the back of the ring and are bent to fit the posterior and lateral aspect of the head closely and a band of webbing is passed from one upright to the other and about the forehead.

In applying the support the chin should always be tilted slightly upward in order to throw the weight of the head backward. (Fig. 39.)

The adjustment of the head support is made easier if the pivot is attached to the upright by means of a ball and socket joint (Shaffer) (Fig. 29) that may be regulated by a screw and key; this arrangement is of service when the head is distorted but it is by no means necessary.

Fig. 39.

The Taylor brace and head support applied to the patient shown in Fig. 38.

Fig. 40.

The Taylor brace with jury mast.

When the Taylor head support and similar appliances are used the greater part of the pressure is sustained by the chin which may, after a time, undergo an unsightly recession. It may be of advantage therefore in certain cases, particularly when restraint of the motion of the neck is desirable to transfer this pressure to the forehead and occiput by extending the back bars upward over the back of the head as in Fig. 47.

A jury mast may be used to support the head also; its adjustment will be described in connection with the plaster jacket with which it is usually associated. (Fig. 40.)

The Plaster Jacket.—It was at one time claimed that a plaster jacket applied while the body was partially suspended, would actually relieve the weakened area of superincumbent weight, by holding the diseased surfaces apart. This is not the fact. The jacket supports the spine as does the brace, by holding it in the erect or extended position. One is a circular and the other is a posterior splint. There is this difference however, the brace fits the spine accurately and holds its place by pressure and friction; the jacket is held in place by the support of the projecting pelvic bones; it lacks the accuracy of adjustment of the brace at the seat of disease, but on the other hand it provides a solid support on the front and sides of the body.

Each appliance has advantages and disadvantages that become apparent in the treatment of certain phases of the disease or conditions of the patient.

The plaster bandage is a simple support, whose efficiency depends upon the accuracy of its adjustment to the irregularities of the body, and upon the leverage that it exerts above and below the point of disease. It should be applied while the body is held in the best possible position; its inner surface should be smooth, and the bony prominences that are susceptible to friction and pressure should be protected.

A seamless shirt should be worn; these are made in several sizes and are sold by the yard at a low price. The shirt should fit the body closely and should be long enough to reach to the knees. The patient is then placed upon a stool, and the halter of the suspension apparatus is carefully adjusted; the arms are extended over the head and the hands clasp the straps or rings; thus the chest is expanded to its full limit. Sufficient tension is made upon the rope to partially suspend the body and to draw the spine into the best possible attitude; in most instances the heels should be slightly lifted from the stool.

Dr. Sayre, to whom we are indebted for the exposition of this valuable means of treatment, insists that the sensations of the patient should be the guide, and that traction should be made only to the point of comfort. This is a valuable indication in the treatment of the adult, but it is not often of service in childhood.

Before applying the plaster bandage, pieces of piano felting or canton flannel of sufficient size are placed about the anterior pelvic spines, over the upper part of the sternum and a thin strip is sometimes used to cover the spinous processes. Finally long strips of saddler's felt, or of other material of sufficient thickness, are applied on either side of the prominent spines to protect them from friction and to provide greater pressure and fixation at the seat of disease. The "dinner pad" is now very rarely used, except in the treatment of adults, and in certain cases of deformity, in which the abdomen is retracted. In childhood the abdomen is usually prominent, and as the jacket expands somewhat after its application no extra space is re-

quired. The pad, which is supposed to represent the space necessary after a full meal, is made by folding a small towel into the shape of a sandwich; this is attached to a bandage and is placed beneath the shirt just below the ensiform cartilage; when the jacket is completed it may be drawn out, by means of the hanging bandage, leaving the additional space for emergencies.

The materials for the jacket should be of the best. Fresh dental plaster should be rubbed by hand into strips of crinoline, free from glue. The bandages should be from three to five inches in width, and six yards in length; from three to six being required for a jacket, according to the size of the child. They should be placed on end, in a pail of warm water, one at a time as they are used. No salt or alum should be used to hasten the setting of the plaster, in fact, if such aid is necessary, it is unfit for use. When the bubbles have ceased to rise, the bandage is squeezed gently until no water drips from it and the loose threads are removed from the ends.

One person should sit behind the patient, and one in front, while a third may hold the rope and check the swaying of the body. The one who sits behind the patient may clasp the child's legs between his knees and thus assure better fixation of the pelvis. The pads are held in position until they are fixed by the plaster bandages, which should be applied with a slight and even tension.

As a rule the jacket should be of uniform thickness throughout. This thickness need not exceed one eighth to one-fourth of an inch and it may be even lighter in certain cases. It is well to make the first turns about the waist and to use the first bandage about the pelvis since the pelvis is the base of support; and as the most important point for counter pressure is the chest, this part should be made especially strong.

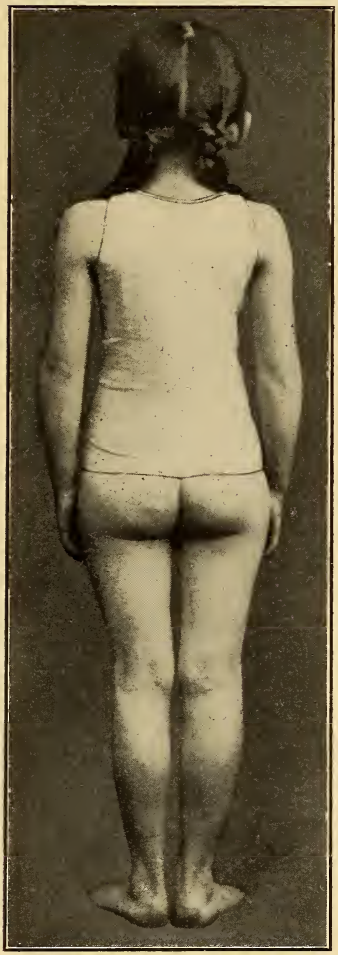
During the application of the jacket it should be rubbed constantly, in order that the different layers of bandage may adhere to one another, and that it may fit the projections of the pelvis and body closely. Meanwhile the attitude of the patient should be carefully watched, in order to prevent lateral inclination of the body. In some instances it is possible to lessen the deformity in the dorsal region, by the extension, and by backward traction on the shoulders, while the jacket is hardening.

When the jacket is nearly firm, it should be trimmed. In many instances this may be done while the patient is in the swing, but if he is fatigued he may be placed in the recumbent posture.

As a rule the front of the jacket should reach from the upper margin of the sternum to the pubes; behind, from the spines of the scapulæ to the gluteal fold; laterally it should be cut away sufficiently to prevent chafing of the arms; and on either side of the pubes an oval section is cut out, to allow for the flexion of the thighs in the sitting posture. Particular attention is called to the importance of making the jacket as long as possible, so that the abdomen may be contained within it, instead of being forced out beneath its lower border. (Fig.

42.) After the application of the jacket, the patient should remain in the recumbent posture for at least half an hour. A much longer period of recumbency is always advisable as it does not become absolutely firm for several hours. The shirt is then drawn up over the jacket and is sewed to the neck portion; this adds much to neatness and cleanliness. The shirt must be drawn tightly about the neck, in order to guard

Fig. 41.



The plaster jacket.

Fig. 42.

The plaster jacket supporting the abdomen.

the body from the crumbs or other objects that may fall beneath the jacket, and in many instances a special protector in the form of a wide collar bib, may be used with advantage. (Fig. 41.)

It may be mentioned in this connection that even the slightest excoriation or irritation of the skin beneath the jacket, can be at once

detected by the peculiar odor. Of this parents should be informed, so that it may be cut down and the source of the irritation removed at once. With ordinary care, "sores," the bugbear of the plaster jacket, are of little consequence.

If the disease is of the middle region of the spine, backward traction on the shoulders is indicated, by means of the anterior shoulder brace described in connection with the spinal brace. (Fig. 43.)

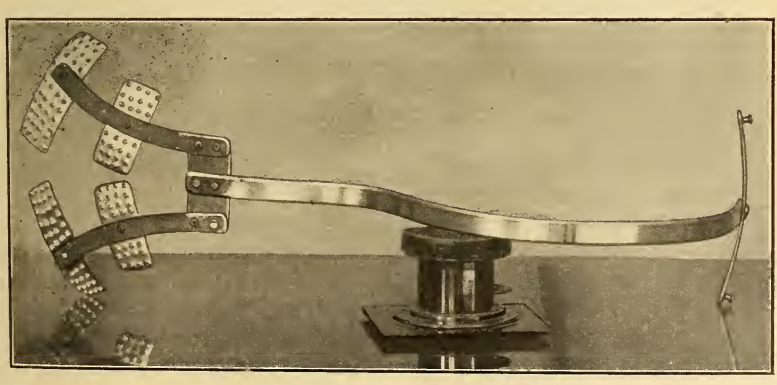
In many instances a head support is required, and it is of course always indicated in disease of the upper dorsal and cervical regions. For this purpose the jury mast is most often employed.

The jury mast should be of tempered steel, strong enough to hold its shape under the tension of the halter. (Fig. 44.) Its base should be incorporated firmly in the jacket below the seat of disease; it should be long enough to reach well above the head and the crossbar should be placed directly over the ears. (Fig. 45.)

Fig. 43.

The jury mast and the anterior support.

Fig. 44.



Jury mast.

The halter should be applied with as much tension as can be borne comfortably by the patient, so that the weight of the head may be at

least partly supported and the chin should be tilted slightly upward, the aim being to draw the head backward and thus to extend the spine. In disease of the cervical region the crossbar should be fixed to check lateral motion of the head, but this is unnecessary when the disease is at a lower level.

The Application of the Jacket in the Recumbent Posture.—The jacket may be applied while the patient lies extended in the prone posture, by the *hammock* method suggested by Davy of London.

FIG. 45.

The jacket and jury-mast applied. The same patient is shown in Fig. 28.

A long narrow strip of cotton cloth is passed under the shirt and the two extremities are drawn tight enough, by means of a pulley, to support the child in the proper attitude. An opening is cut for the face and, if advisable, traction may be made on the arms and legs of the patient. The bandages are then applied in the ordinary manner after which the cloth may be cut short at one end and removed.

This procedure is of service in the treatment of weak or paralyzed patients, but the adjustment is somewhat less accurate than by the ordinary method. The jacket may be applied in the supine posture by means of the *Goldthwait* support. This latter method may be employed with advantage in the routine application of the plaster jacket. (Fig. 46.)

The Application of the Jacket to Patients who have been Treated on the Stretcher Frame.—A very satisfactory method of applying a plaster jacket in young subjects, whose deformity has been corrected in whole or part by recumbency on the frame in the over-extended position, is the following. The patient is suspended face downward in the horizontal position by two assistants, one holding the arms and the other the thighs; thus a certain amount of traction is exerted while the weight of the body tends to over-extend the spine.

In this attitude a jacket is quickly applied, and the child is at once replaced upon his frame which has been protected by a rubber

FIG. 46.

The routine method of applying the plaster jacket in the horizontal position by means of the Goldthwait appliance. The essential part of the apparatus is shown in duplicate in the foreground (A). Upon its upper extremities two thin bands of steel, similar to those used in the Taylor brace, are placed (B), to support the pads which protect the spinous processes at the deformity. The child is placed upon the support, as illustrated in the figure, and the plaster bandages are carried about the body on either side of the support, including the pads. When the jacket is firm the patient is lifted from the support. By this method a certain amount of leverage is exerted upon the deformity, but less than when the other forms of the appliance are used. See Figs. 58, 59 and 60.

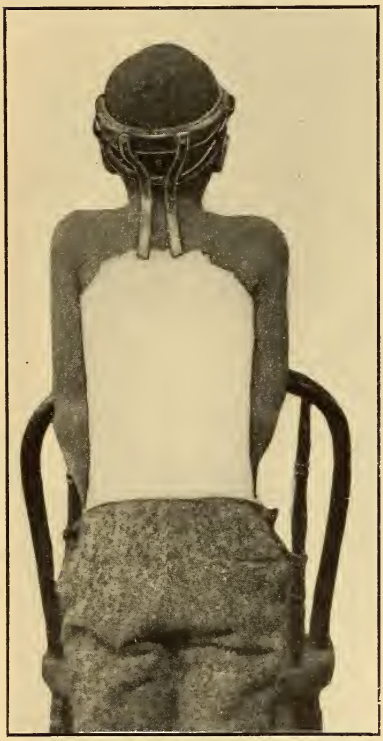
sheet. Thus the plaster jacket, during the hardening process, must conform to the habitual posture of recumbency. In addition, the pressure pads of the frame indent the bandage on either side of the spinous processes (Fig. 48) and thus assure better support and fixation. This is a very effective method of applying the jacket in this class of cases, because it is not necessary to retain the child in an uncomfortable position while the bandage is hardening, and because accuracy of adjustment in the best possible attitude is assured.

As a rule a jacket may be worn for two months, although not infrequently in hospital practice it may remain for six months, or even

longer, and yet be fairly efficient. Usually one jacket is removed and another applied on the same day, but if the skin is at all sensitive it is well, after the washing and powdering, to re-apply the old jacket, closing it with adhesive plaster, and allow an interval of a few days before applying the permanent one.

The Plaster Corset.—In the stage of recovery the jacket may be replaced by a corset. A jacket, made and trimmed as already described, is cut down the center and removed from the body. It is carefully

FIG. 47.



A fixation support for the head. This may be used with the brace or with the jacket.

FIG. 48.

Jacket applied by the stretcher method, showing the depressions in the jacket caused by the frame pads.

readjusted to its former shape, bandaged with the cut surfaces in close apposition, and is thoroughly dried or baked. All wrinkles are then cut away from the inner surface, and extra padding is applied if necessary; the shirt is drawn tightly about the borders of the jacket and strips of leather provided with hooks are sewed in front so that it may be laced like an ordinary corset. It may be removed, from time to time, to allow for bathing, but it should always be removed and reapplied while the patient is suspended or in the recumbent position.

Corsets are often used in place of the jackets in the treatment of the

active stage of the disease, but they are less effective, since the repeated stretching during their removal and reapplication weakens them and impairs the accuracy of adjustment; and, in addition, one of the strongest arguments in favor of the use of plaster of Paris, that treatment is under the control of the surgeon, is nullified.

Comparison of the Two Forms of Ambulatory Support.—The most severe criticisms of the jacket have been made by those unfamiliar with its use, on theoretical grounds rather than from actual observation. While it is admitted that there are certain objections to its use, yet experience shows that when it is applied in a proper manner under proper conditions it is a thoroughly reliable, efficient and often indispensable means of treatment. Indeed, it may be stated that by means of the jacket and the Bradford frame it is possible to treat nearly every case of Pott's disease without the aid of the professional bracemaker, and with success.

It is evident, however, that under certain conditions the jacket must be inferior to the brace, in early childhood, for example, when the pelvis is not sufficiently developed for proper support. Again when the disease is low down, at or near the lumbo-sacral junction, the lower border of the jacket does not hold the pelvis with sufficient security to provide the proper fixation. In the upper dorsal region the attachments for accurate fixation may be more readily applied to the brace, and in disease of the cervical region the metallic head support is to be preferred to the jury mast, for the reason that it cannot be removed by the patient as can be the straps of the halter. The traction of the jury mast is very effective when properly used and particularly so, when painful distortion of the head is present, but the tension on the straps is rarely constant and thus it loses in effectiveness. A rigid support is, of course, essential in disease of the atlo-axoid region.

The jacket will be found to be most efficient in disease of the spine from the tenth dorsal to the second lumbar vertebra. It is not only effective but it is often a more comfortable support than the spinal brace. It is also more efficient than the brace when lateral deviation of the spine is present; and from the clinical standpoint, it is often more efficient in relieving the symptoms of pain in this region, when the disease is at all acute.

One may conclude, then, that each form of support may be used according to the indications. The absolute control of the treatment, assured by the use of the plaster jacket will often over-balance the claims of the brace; in practice among the poor, when choice of means is not always permitted, it is indispensable; and it may be used with fair success, even under conditions that theoretically contraindicate its employment.

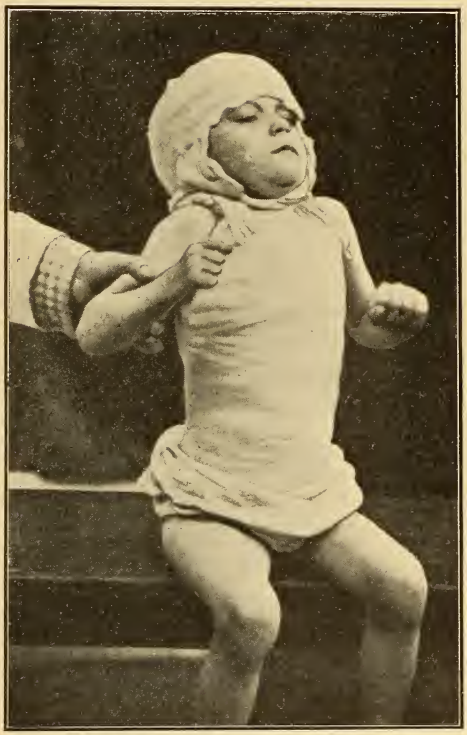
Modifications of the Jacket.—Occasionally, the form of the jacket may be changed to meet special indications; for example, backward traction may be secured by carrying the bandages over the shoulders; or the head may be fixed in the support, if the jury mast is not at hand (Fig.

49); or one or both thighs may be included in a spica jacket in painful disease of the lower region, when psoas spasm is a symptom. Such modifications are required rather for temporary emergencies than for continuous treatment.

Dr. H. L. Taylor has recommended what he calls the bivalve plastic splint of plaster of Paris.

"A paper pattern of the posterior valve is made from the patient's back allowing one inch extra around the edge to be folded back. From this pattern eight or ten thicknesses of crinoline are cut of the same size and shape. The patient being supported face downward on a rest under the pelvis and another under the upper part of the sternum, the crinoline sheets are dipped into plaster cream in a large flat pan, applied to the back, the felt pads being in position; the edges are folded back for greater rigidity and the whole carefully moulded to the patient and allowed to set, after which the patient is turned on his back and the anterior valve made in a similar manner.

FIG. 49.



Plaster bandage including the head to hold the spine in the extended position after the correction of deformity.

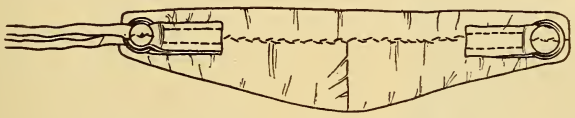
"The jacket should be made firm and rigid, especially at the edges, and should reach in front from the pubes to the top of the sternum. Such an apparatus is rigid, removable and adjustable and brings the pressure to bear on definite areas selected with regard to its mechanical action. The splint may be removed to cleanse the back or to note its efficiency, taking the impressions made by the felt pads either side the spinous processes as a guide. If more leverage is needed, the felting may be reinforced or the depth of casing reduced by paring the lateral edges. In other words the jacket has ceased to be mainly a casing and has become a mechanism under the surgeon's control and capable of being manipulated to produce definite mechanical results."

Corsets of Other Material than Plaster of Paris.—Corsets of wood, leather, paper, poro-plastic felt or celluloid are sometimes used. These

are constructed on a plaster cast of the body, a thin accurately fitting jacket being used as a mould.

Such corsets have certain advantages of durability. and elegance, but none of them has the accuracy of fit of the plaster of Paris corset, which is moulded directly on the body by constant manipulation during the stage of solidification. Corsets of this class are usually somewhat expensive, and on that account are often worn after they are outgrown or no longer fit the patient. Their use is practically limited to the stage of recovery or for other affections than Pott's disease.

FIG. 50.



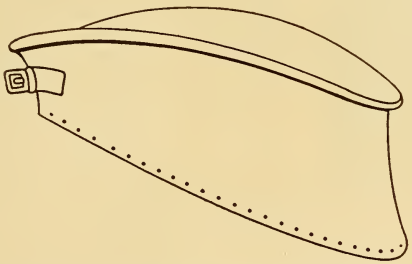
The Thomas collar. (RIDLON AND JONES.)

Of these corsets, one of the best is that used by Weigel, of Rochester, made of alternate layers of linen cloth and wood pulp matrix paper, fixed by a mixture of paste and glue.

A more durable corset may be constructed of aluminum, as advocated by Phelps. This may be obtained in thin sheets, which may be hammered upon the plaster cast into the proper shape. The two halves are attached by hinges in the back and are perforated to allow for ventilation.

In the final stage of treatment, the Knight brace, a light steel frame with corset front may be employed (Fig. 132), or a long corset similar

FIG. 51.



The Thomas collar. A piece of thin sheet metal is cut wide enough to reach from the sternum to the chin and from the back of the neck to the base of the occiput. The edges are turned out and the whole properly covered with felt and fitted. (RIDLON AND JONES.)

to that ordinarily worn by women, but strengthened by the insertion of light steel bars along the spine, is often sufficient.

Other Forms of Support.—In certain cases of disease of the lower lumbar region of the spine, it may seem advisable to restrain the movements of the thighs, although ordinarily, when this is necessary the patient should be placed upon the frame. Such restraint may be

attained by making the back bars of the brace stronger and extending them down the back of the thighs to the knees like a double Thomas hip brace.

If the jacket is used, it may be extended to a single or double spica for the same purpose, as has been mentioned. Such appliances are useful when psoas spasm and "cramp" are troublesome symptoms.

In disease of the cervical region a certain amount of support and fixation may be obtained by collars of poro-plastic felt, plaster of Paris or other material. The *Thomas collar* is the best of this type of support, but none of them is thoroughly efficient unless used with a brace to control the larger movements of the spine. They are useful in emergencies but they are not often required when proper braces can be obtained.

FIG. 52.

The Thomas collar applied. (RIDLON AND JONES.)

Many other forms of apparatus of greater or less merit might be described, but space has only permitted a detailed account of three forms that, it would seem, best represent the essential principles involved in the treatment of Pott's disease.

The Principles of Treatment in Their Practical Application.—After the description of the special forms of appliances used in the routine treatment of Pott's disease, one may consider with advantage the treatment in its more direct relation to the patient. The object of this treatment is to relieve the symptoms, to maintain and to improve the vital resistance of the patient, to check, to remedy and to prevent deformity. Under favorable conditions the death rate is small, and pain is easily relieved, but prevention of deformity is often extremely difficult.

The effect of treatment must be estimated not simply by its relief of the symptoms of the disease, since deformity may steadily advance in spite of the apparent well-being of the patient, but it must be selected and continued or changed with the aim of combating ultimate deformity, and on this standard success or failure must be determined. It is probable that noticeable deformity might be prevented, nearly always, if treatment were applied in season. But practically such opportunity is not often offered, and the local deformity that represents destruction of bone, may be considered as irremediable. There is also a dwarfing and blighting effect of the disease, which, although it is

usually associated with marked deformity, is always to be feared, particularly when the disease affects the middle or lower region of the spine in early childhood, and is severe and prolonged in its course. By proper treatment one may hope to check the progress of the disease and even to remedy the deformity in great degree, by freeing the spine from the deforming influence of local disease, and by preventing or removing the symptomatic distortions such as psoas contraction or wry neck.

Indications for Treatment by Recumbency.—As has been stated already, the most important influence toward deformity when the spine has been weakened by disease, is the force of gravity; therefore horizontal fixation is the most efficient means of preventing deformity, and it assures the rest for the diseased spine that favors repair.

This is then the treatment of last resort, the treatment for emergencies and in many instances the treatment of choice and routine. It is indicated as the routine treatment in infancy, and in early childhood up to the age of three years, at least during the acute and progressive stage of the disease, because the structure of the spine offers but little resistance to the extension of the destructive process, and because prolonged disease and deformity are much more disastrous at this age of rapid growth than at a later period.

The time that this treatment should be continued is determined by the character of the disease, by the presence or absence of complications and above all by the condition of the patient. A year would perhaps represent the average time that horizontal fixation may be employed with advantage in appropriate cases. When the frame is used in the manner described, and when the child is taken regularly into the open air, the general condition almost always improves with the complete relief of the pain, weakness and discomfort that the treatment assures.

FIG. 53.

Final result of lumbar disease; spontaneous absorption of abscess, and but slight deformity. See Fig. 13.

If the progress of the local disease is toward repair, the patient becomes restless, he no longer lies motionless when he is removed from the frame, but turns and twists the body in a manner that shows the absence of muscular spasm. At this time it is well to fit the back brace that is to be used when the frame is discarded, provided it has not already been used in conjunction with the hori-

zontal fixation; then little by little the upright posture and ambulation are resumed.

FIG. 54.

Pott's disease of the middle dorsal region, a type of disease in which horizontal fixation is always indicated. H. S., age 14 months.

In many instances absolute recumbency may not be required, but the period of activity must be carefully regulated, and must be discon-

FIG. 55.

H. S. after 14 months of fixation on the modified Bradford frame, shows the recession of deformity. Compare with Fig. 54.

tinued when there is evidence of discomfort or weakness or pain. If the period of activity must be short, it should be passed in the open air. The passive attitude of sitting, although less strain is thrown upon the spine than during activity, may be even worse for the patient; thus the reclining or semi-reclining posture should be assumed, as a rule, when the child is in the house, at least during the active stage of the disease. Even if the patient appears to be perfectly supported, the time spent in bed should be long, and a period of rest in the middle of the day should be enforced.

The arguments in favor of horizontal fixation in early childhood do not apply to disease in the adult. At this age the structure of the spine is resistant, and deformity is little to be feared, while such confinement would be irksome and impracticable; thus local support, supervision and, if possible, a change of climate, must be the treatment of selection for the adolescent or adult.

In the middle period, from the third to the tenth year horizontal fixation is the treatment for emergencies; for paralysis, for abscess, for dangerous disease of the atlo-axoid region, for progressive deformity, and for pain that cannot be relieved by the ordinary means.

Special Indications for Treatment of Disease of the Different Regions of the Spine.

In the selection of treatment, and in the general management of Pott's disease each region of the spine must be judged by itself, since in each there are special difficulties to be met, and complications to be feared, that may influence the prognosis and lead to modifications of the routine of treatment.

The Lower Region.—The prognosis is good in disease of the lower region, the symptomatic attitude is favorable, the part may be easily supported, the cases are often seen before the deformity is at all extreme, and one may, as a rule, predict recovery without noticeable deformity or at most a slight shortening and broadening of the body and a peculiar erectness of attitude.

Uncomplicated cases may be treated with the brace or jacket. The brace is the better support when the disease is near the sacrum, while the jacket is often more comfortable and more effective than the brace when the middle and upper lumbar region is diseased, particularly when lateral deviation of the spine is present. Whenever the tendency to psoas contraction is at all marked or when pain or cramps in the legs are complained of, the period of activity should be carefully restricted; in fact the "night cry" is an indication for a day of rest in bed.

The most troublesome complications of this region are psoas contraction and the abscess with which it is often combined.

As has been stated, psoas contraction changes the attitude of over-erectness, favorable to repair, to a forward stoop that increases the pressure and friction at the seat of disease. If this attitude persists

and if it becomes fixed by permanent changes such as are likely to follow the burrowing of a pelvic abscess, the result is one of most disastrous deformity, the body and the legs are approximated and the erect attitude is made impossible. In neglected cases of this character, tenotomy and forcible correction or even subtrochanteric osteotomy may be necessary to overcome the secondary deformity.

In ordinary cases of psoas contraction, and when one leg only is flexed, the patient may be allowed to go about using a high shoe on the unaffected side and crutches, so that the flexed leg need not affect the attitude. If, however, the contraction persists, it is well to place the patient on the frame, and to reduce the flexion by traction in the line of deformity, as will be described in the treatment of disease of the hip joint. Persistent psoas contraction is almost always a symptom of abscess about the origin or in the substance of the muscle, and when it is accompanied by pain, it is always an evidence of active disease.

Abscess may be expected as a complication in at least 50 per cent. of the cases of disease of this region, but it is by no means always accompanied by psoas contraction, any more than psoas contraction is always caused by abscess. Abscess unaccompanied by contraction more often has its origin above the lumbar region, so that in its descent it passes along the surface but does not involve the substance of the muscle.

Attention is especially called to the fact that the bad results of Pott's disease of this region are almost invariably caused by allowing flexion of the legs, whether it be symptomatic of abscess or not, to persist, therefore the importance of preventing and correcting this deformity cannot be over-estimated. It should be stated, however, that in dispensary practice, when special care cannot be provided, one often sees psoas contraction that may have persisted for months relax, if the progress of the disease is favorable, without treatment other than the routine fixation of the spine by the brace or jacket. In certain cases, one or both thighs may be fixed by the plaster bandage or by the back bars attached to the brace, when pain and spasm are troublesome, but as a rule rest on the back until the acute phase of the disease has passed is to be preferred.

The Lower Dorsal Region.—Disease of the lower dorsal region, the middle of the back, is very favorably situated for effective mechanical treatment, and psoas contraction and abscess are much less troublesome than in the lower part of the spine. The brace or the jacket is an efficient support, and the symptoms are, as a rule, easily relieved.

Deformity sometimes increases, almost imperceptibly, by a progressive forward bending or lordosis of the flexible lumbar spine below the projection. One must guard against this by applying the jacket firmly while the spine is made as straight as possible, or if the brace is used, the lumbar spine should be drawn firmly against it.

If lateral inclination of the body is so marked as to interfere with the proper application of a brace, preliminary rest in bed is indicated. Lateral deviation can be corrected as a rule by the jacket without re-

cumbency, although this, as other forms of symptomatic distortion, should be treated ordinarily, if not by complete rest, at least by careful regulation of the period of activity.

Disease of the Middle and Upper Dorsal Region.—This is, from the standpoint of prevention of deformity, the most difficult region of the spine to treat, although the symptoms of the disease may be easily relieved.

Deformity is present in nearly all cases when treatment is sought, and, deformity having begun, is very difficult to check, for the reasons that have been already stated.

The final result in the majority of cases is what appears to be exaggerated round shoulders ; the neck is shortened and projects forward, the chest is flat and the shoulders are high.

It is only by an early diagnosis and by efficient and long continued treatment that recovery from disease in this region without noticeable deformity, may be hoped for.

In all cases of disease above the ninth vertebra, the anterior brace for backward traction of the shoulders may be used with great advantage to secure greater fixation of the spine ; and in all cases above the seventh or eighth vertebra a head or chin support to restrain the forward inclination of the neck is indicated in addition.

With the plaster jacket the jury mast is employed, with the brace the looped chin rest or the ordinary Taylor support may be used.

In disease of the middle and upper dorsal region the brace is to be preferred to the jacket because of the greater accuracy of adjustment, and because the halter of the jury mast is rarely retained in proper position when the patient does not, as in these cases, feel the need of such support.

In this region of the spine, *paralysis* frequently occurs as a complication. When it appears after treatment is begun, it is usually a result of inefficient fixation of the spine or of want of caution in regulating the strain to which the diseased part is subjected. Its symptoms and its treatment will be considered later.

Disease of the Upper Dorsal and Middle Cervical Region.—This is the most favorable region of the spine for treatment. The disease is usually not extensive because of the small size and compact structure of the vertebræ ; and the mobility of the cervical region is so great that it readily compensates for the local rigidity.

Under efficient treatment one may predict recovery without noticeable deformity and in the less successful cases the deformity is not, as a rule, offensive. The shoulders appear high, the neck is short, the head inclines forward while the back is abnormally flat in compensation for the change in contour of the part above.

When the case of cervical disease is first brought for treatment, a *wry neck* deformity, often made more persistent by the infiltration of an abscess or by inflamed cervical glands is almost always present. As a means of correcting this distortion, the jury mast and traction halter, attached to the jacket or brace is a very efficient and comfortable

support. Under the constant tension the deformity is, as a rule, very quickly corrected, but as a permanent treatment, the brace and head support are to be preferred to the jury mast, because a more exact fixation is assured; for, as has been stated, although the jury mast, when properly applied and adjusted, is an admirable support, yet under other conditions it is absolutely worthless.

The distortion of the head may be overcome also by traction in bed, and it will usually disappear under simple fixation. The use of collars of felt or leather has been mentioned. With the brace these are unnecessary, but they may be used with advantage to add to the efficiency of the plaster jacket and jury mast.

Disease of the Occipito-Axoid Region.—Under efficient treatment the prognosis is good, and recovery without deformity should be the rule. The course of the disease, although it is often accompanied by acute symptoms, is usually short as compared with that of other regions of the spine; and it may be assumed that, in many cases, it is a primary arthritis, or at least that the primary focus in the atlas or axis is very small. The disease at this point is however in close proximity to the vital centers, and sudden death from displacement of the weakened parts is not uncommon. Abscess is frequent and it is often a troublesome and dangerous complication.

As has been mentioned, wry neck deformity is a very constant symptom, and there is also a strong tendency toward a forward and downward inclination of the head, so that in neglected cases the chin may rest upon the chest. The indications for treatment are to overcome the distortion and to hold the head fixed in the middle line, the chin being somewhat elevated above the right-angled relation with the spine. In the mild cases the jacket-and-jury-mast traction may be used to overcome the distortion, but the metallic head support with the fixation attachment, to prevent motion in the diseased joints, is always indicated as the treatment of selection because by such apparatus the danger of displacement may be avoided.

When the disease is acute in character, and especially if abscess be present, recumbency on the frame with fixation of the head and slight traction by the weight and pulley, or by the jury mast attachment, is indicated. Traction should not be sufficient to cause discomfort; counter traction may be supplied by the weight of the body and by slight elevation of the head of the bed. The head sling is of the form used with the jury mast, or a simple band about the head may be used. Under this treatment slight deformity of any part of the cervical region will practically disappear, and as a rule the course of the disease is very favorably influenced by it.

In certain cases of disease of this region, accompanied by acute symptoms, the attitude of recumbency is extremely uncomfortable. The discomfort is caused apparently by the forward projection of the upper part of the spine, so that when the head is drawn upward and backward in the recumbent attitude the calibre of the throat is lessened. In other instances the pain may be due to pressure of the atlas against

the odontoid process of the axis. In such cases, if recumbency is desired, the head must be elevated by pillows to the point of comfort, the support being removed when the child has become accustomed to the position, or when the deformity has been corrected.

The Complications of Pott's Disease.

Abscess.—It may be assumed that a limited collection of tuberculous fluid is present at some time during the course of Pott's disease in the great majority of cases, but unless it appears as a palpable tumor above or below the thorax or upon the surface of the body its presence is not often detected.

Townsend,[1] in 380 cases of Pott's disease examined with reference to the occurrence of abscess as a complication, found that it was present or had been detected in 75 (19.7 per cent.), in 8 per cent. of the cases of cervical disease, in 20 per cent. of the dorsal and in 72 per cent. of those in which the lumbar region was involved.

Dollinger,[2] in 700 cases under treatment from 1883 to 1895 found abscess in 154 (22 per cent.); in 13 of 63 cases in the cervical region (22.6 per cent.); in 47 of 403 cases in the thoracic region (11.6 per cent.) and in 94 of 234 cases of lumbar disease (40.17 per cent.).

Ketch,[3] in 75 cured cases of Pott's disease treated at the N. Y. Orthopædic Dispensary, selected for the purpose of contrasting the behavior of the disease in the different regions of the spine found that abscess had appeared in 19 (25.3 per cent.). In the upper region abscess was detected in but one of the 25 cases (4 per cent.); in the middle region in 8 of the 25 cases (32 per cent.) and in the lower in 10 (40 per cent.).

In 354 autopsies by Mohr, Nebel Bouvier and Lannelongue abscess was found in 281 or nearly 80 per cent. Although cases of Pott's disease that come to autopsy may be supposed to represent a severe type of disease yet it is evident, by contrasting the statistics, that a large proportion of the abscesses escape detection in the living. One may conclude then, that abscess may be expected as a more or less serious complication in 25 per cent. of all cases of Pott's disease, and in at least half of those in which the lower region of the spine is involved, the greater frequency here, being explained by the large size and less resistant structure of the vertebral bodies, as compared with those of the upper regions.

The tuberculous abscess is separated from the neighboring parts by a limiting wall of more or less thickness, according to its age, the outer layers of which are of fibrous and cellular tissue, the inner of granulation tissue covered with yellowish-gray or pinkish-gray necrotic membrane which is easily separated from the underlying parts. The fluid of the abscess is of a whitish or whey-like color composed of

[1] Trans. Am. Ortho. Ass'n, Vol. IV., p. 166.
[2] Dollinger, loc. cit.
[3] Trans. Am. Ortho. Ass'n, Vol. IV., p. 200.

serum, leucocytes and emulsified caseous material and fibrin ; floating in it are larger masses of cheesy necrotic tissue and sometimes minute fragments of bone. This more solid material settles to the bottom of the glass if the fluid is allowed to stand. The fluid of quiescent abscesses or those that are in process of resolution is often clear, like serum, but if secondary infection has taken place the pus is of a greenish-yellow color, and is of uniform consistency. At any stage of its progress the abscess may become stationary and its contents may be absorbed, in fact such an outcome is not unusual ; the fluid of the abscess is usually sterile and secondary infection, before a communication with the exterior of the body is established, is comparatively rare.

It has been claimed that abscess formation is always the result of infection with pyogenic germs, but this may be doubted, since the ordinary tuberculous abscess may be sterile or at most contain but a few tubercle bacilli. It is very certain, however, that the formation and increase of the abscess is favored by irritation and injury, and that the most effective treatment of this complication is to support the diseased spine and to relieve it from over-strain.

Abscess is a symptom of disease and is, in some degree, an evidence of its character. If it appears early and increases in size rapidly, it usually indicates a destructive and rapidly advancing process, or infection from without. On the other hand, the slowly enlarging or quiescent abscess has but little significance.

In many instances the abscess causes no symptoms whatever, or it may be a source of inconvenience simply because of its size or situation. In other cases, a period of malaise or discomfort or pain is followed and explained by the appearance of an abscess, but whether the symptoms were caused by the tension of the abscess or by a more acute phase of the disease itself, is not always clear.

Large abscesses, which are increasing in size and approaching the surface are usually accompanied by pain, and by elevation of temperature, that indicates probably a slight degree of secondary infection, but otherwise the ordinary deep abscess appears to have no other effect than to add, doubtless, to the susceptibility of the patient.

The Course and Peculiarities of Abscess in the Different Regions of the Spine.—The tuberculous abscess may remain as a small collection of fluid in the neighborhood of the disease where its presence may be detected only by percussion or by deep palpation. As a rule, however, it slowly increases in size, and under the influences of the force of gravity and the tension of its contents it finds its way down the spine or toward the exterior of the body, following the path of least resistance. The abscesses which have passed below the diaphragm or which have originated below this point may follow various paths. Some enter the sheath of the psoas muscle and finally make their appearance on the inner aspect of the thigh, *psoas abscess*. Others perforate the sheath of the quadratus lumborum muscle and form a *lumbar abscess* projecting between the twelfth rib and the crest of the ilium at the triangle of Pétit. Those abscesses that escape from the fascia of the psoas muscle

or that pass downward on the surface of the iliac fascia, the so-called *iliac abscesses*, often form a tumor over the outer extremity of Poupart's ligament at the junction of the transversalis and iliac fasciæ, or the fluid may follow the course of the iliac artery to the thigh, or, escaping from the greater sacro-sciatic foramen, form a *gluteal abscess*.

Iliac or psoas abscess is most often confined to one side but it may be bilateral, the two sacs communicating with one another by a larger or smaller channel. In the *thoracic region* the abscess may remain indefinitely in the posterior mediastinum, where, if large, its presence may be demonstrated by an area of dullness extending toward the lateral region of the thorax or it may perforate the intercostal muscles and appear on the posterior or lateral aspect of the chest, or it may pass downward through the aortic opening in the diaphragm and become an iliac abscess.

FIG. 56.

Bilateral lumbar abscess.

Abscess caused by disease of the *occipito-axoid* region may force its way forward between the recti muscles and appear behind the pharynx as the retro-pharyngeal abscess, or the fluid may take the opposite direction and distend the sub-occipital triangle and then pass forward to the region of the mastoid process. In other instances the abscess may dissect its way about the base of the skull or pass upwards through the foramen magnum or downward into the spinal canal.

Abscesses from the *middle cervical region* usually pass outward between the scaleni and longus colli muscles to the interval between the trapezius and sterno-mastoid, perforating the skin about the middle of the lateral aspect of the neck near the anterior border of the latter muscle.

These are the paths usually followed by the tuberculous fluid, but occasionally it may enter the spinal canal or break into the pleural cavity or lung or intestine or by the side of the rectum or elsewhere.

Treatment of Abscess.—Abscess is by far the most troublesome and dangerous complication of Pott's disease. It may interfere with proper mechanical treatment, and it is often a cause of permanent as well as temporary deformity, especially in the lower region of the spine as

has been stated. It prolongs the course of the disease by extending its boundaries and although it is not often a direct cause of death, yet many patients die because of the exhaustion of long-continued suppuration that may follow secondary infection and of the amyloid degeneration that may finally result.

A large abscess is always a source of danger because of the possibility of secondary infection of its contents before it finds an outlet and because of the probability of infection, when a communication with the exterior has been established. Abscess is however a symptom and result of disease and in properly treated cases it is as a rule a complication of comparatively slight consequence. If abscess is not present when treatment is begun, one may hope to prevent it by effective protection of the spine, and if it be present, this protection should be all the more rigidly enforced.

The surgical treatment of the abscess of spinal disease is very difficult, not because it is different in character from other tuberculous abscesses, but because it is as a rule impossible to remove the disease of which the abscess is a symptom ; and incomplete or ineffective surgical operations should be avoided.

As the abscess is a symptom of disease so, as a rule, its treatment should be symptomatic. The *retro-pharyngeal abscess* demands prompt evacuation because it is likely to obstruct breathing and swallowing, because its sudden rupture may cause death and because an abscess in such close proximity to the vital centers is always a source of danger. In cases of emergency the abscess may be evacuated by an incision in the middle line of the pharynx, but preferably the opening should be from the exterior. An incision is made along the posterior aspect of the sterno-mastoid muscle in its upper third. The abscess tumor is easily reached by careful dissection and drainage is established which has evident advantages over that into the throat.

Abscesses from the *middle cervical region* usually point in the lateral region of the neck and cause but little inconvenience. Abscesses in the *upper thoracic region* may, in rare instances, cause dangerous pressure on the trachea or lungs as shown by spasmodic attacks of inspiratory dyspnœa, "asthmatic attacks." In some instances an area of dullness near the seat of disease demonstrates the position of the abscess, but if it lies in the median line it can not be detected either by auscultation or percussion. If the inspiratory dyspnœa is well marked the symptom may be fairly attributed to this cause and the operation of costo-transversectomy may be undertaken to relieve the pressure. An incision is made, preferably on the right side, to expose the articulation between the transverse process and the rib ; the joint may be resected or a section from one or more of the ribs may be removed as in the operation for empyæma ; the finger is then inserted and passed along the surface of the adjacent vertebral body until the abscess sac is reached. It is then opened and drained. (Fig. 9.)

In the lower region of the spine operations may be necessary because there is evidence of *secondary infection.* In this event if the

abscess distends the lumbar region or forms a sac on either side of the spine, an opening in the loin on one or both sides of the spine is necessary. This is made as in operations on the kidney, by an incision on the outer side of the erector spinæ muscle between the last rib and the crest of the ilium; the underlying quadratus lumborum muscle is cut through transversely and the abscess cavity is entered. In certain cases, it is possible to expose the spine and to remove fragments of necrosed bone along with the contents of the abscess. As a rule the complete removal of the lining membrane of the abscess is not possible, and one must be content to evacuate the solid and semi-solid contents by flushing with hot water, together with as much of the abscess membrane as may be removed by swabbing with gauze. The most important point in the operation is to provide for efficient and complete drainage of the cavity; if this is assured there is little danger to be apprehended from subsequent infection. Two or more counter openings are usually necessary when the lumbar incision has been made, one just in front of the anterior superior spine and another in the thigh, if the abscess is of the psoas variety. Long drainage tubes are inserted and should remain until a proper channel for the escape of pus has been established.

When the abscess is of one side only, not extending into the thigh, and when the symptoms do not indicate infection, but when its evacuation seems advisable because of its size and tension, it may be opened by an anterior incision below Poupart's ligament just to the inner side of the sartorius muscle. After copious injections of hot water a drainage tube may be inserted long enough to reach to the seat of disease if it be of the lumbar region.

In after-treatment irrigation is not often required; the dressing should be of dry sterile gauze and great attention should be paid to absolute cleanliness and to effective drainage. As soon as is possible, if the discharge has become slight and if the back can be properly supported, the patient is allowed to walk about and to go into the open air. In ordinary cases a slight discharge will persist for several months or longer, depending on the condition of the disease; if however it be quiescent or cured the sinus will promptly close.

In the symptomatic treatment of abscess, *aspiration* is sometimes of service, for by this means it may be prevented from increasing in size; and when the disease is quiescent, the cure of the abscess may follow the removal of its contents which allows the collapse of its walls. When aspiration is employed it should be repeated systematically as often as the abscess cavity refills. After each evacuation pressure should be applied to favor the adhesion of the apposed walls.

When the contents are of such a nature that aspiration is impracticable, an *incision* may be made, through which the semi-solid substance may be removed by vigorous flushing with hot water. The opening is then closed and pressure is applied with the aim of obtaining primary union. This method is sometimes successful, but usually a sinus forms later at the point of incision.

Until recently the *injection of anti-tuberculous remedies* into the abscess sac was in favor. This is probably of value in diminishing the infective quality of the contents, perhaps also, in lessening the danger of mixed infection and in stimulating absorption, although it appears to have little direct effect upon the course of the tuberculous process. An emulsion of iodoform in sterilized oil or glycerine, 10–20 per cent. in doses of from 4–30 grammes is injected at intervals of from two to four weeks, with or without previous evacuation of the contents; the amount and the frequency of the injection depending upon the age of the patient and upon the effect of the treatment. If used with caution as to asepsis, and to the toleration of the patient for iodoform, no harm will follow, even if the treatment proves to be of little practical value.

When an abscess approaches the surface, the skin becomes red and thin and there is usually some local tenderness and pain. Whenever spontaneous evacuation of the abscess is probable, the mother should be instructed as to the necessity of absolute cleanliness, and the proper dressings should be provided. After the abscess has broken, the patient should remain in bed for several days, or until the discharge has become small in amount.

In the symptomatic treatment of the abscesses of Pott's disease, we may conclude then that operation will be indicated in the treatment of the retro-pharyngeal abscess and in the rare instances when dangerous pressure is exerted by an abscess in the posterior mediastinum. It is indicated of course when there is evidence of mixed infection or when the rapidly increasing abscess causes discomfort, or interferes with effective support. It is usually indicated when the abscess is of large size if proper care can be provided. The operative treatment is practically free from danger if cleanliness and efficient drainage can be assured. Aspiration is practically free from danger and is often of service in preventing the enlargement of the abscess and it may hasten its absorption.

While the operative treatment of large abscesses is, under proper conditions, free from danger and is likely to become the treatment of selection and routine in those cases for which efficient after-treatment can be provided, yet in the majority of cases the symptomatic treatment that has been outlined is likely to hold a permanent place, since in large cities there are far more patients who have abscesses than there are hospital beds to put them in. Treatment under such limitations has demonstrated the fact that the abscess is of little consequence when the primary disease has been properly treated. An abscess often exists for months before its presence is detected and after its discovery it may remain quiescent for a long time and finally disappear.

A very large proportion of the abscesses of Pott's disease cause no symptoms, but slowly find their way to the surface of the body. Meanwhile it may be assumed that the disease of the spine, of which the abscess is a result, is in process of cure; so that when the fluid finds an outlet, the source of supply will be shut off and permanent closure of the sinus may follow.

Finally a discharging sinus communicating with the interior of the body, whether it be the result of an operation or not, is always a source of discomfort. It may interfere with effective support, and if the discharge is large in amount it is much more serious in its effect upon the patient than was the abscess when it was contained in the interior of the body.

These are practical arguments that are particularly effective when contrasted with the evidence in favor of the so-called radical treatment that consists in the evacuation of every collection of fluid because it is an abscess, without regard to the general condition of the patient or to the local disease of the bone of which it is a complication.

Paralysis from Pott's Disease.

The tuberculous process in the vertebral bodies may extend backward and breaking through the posterior ligament it may enter the epidural space and press upon the spinal cord; then follows paresis or paralysis of the parts below the constriction. In rare instances the pressure may be due to a fragment of necrosed bone. Not infrequently it is caused in part at least by the pressure of a neighboring abscess, but it is usually the result of the slow advance of the tuberculous granulation tissue. When this has forced an entrance into the spinal canal it sets up a resistant inflammatory thickening of the coverings of the cord, first a peripachymeningitis and then a pachymeningitis, so that in addition to the direct pressure there may be an interference with the blood supply and with the lymphatic circulation. Thus local œdema of the cord may follow and as a later result an increase in the interstitial connective tissue of its substance with a corresponding atrophy of the nervous elements; an ascending and descending degeneration that, in prolonged cases, may terminate in partial or complete sclerosis. The dura mater is a resistant structure and direct destruction of the cord by the tuberculous disease is rare. In fact, as a rule but little permanent damage results even from long-continued pressure and paralysis, for the cord seems in these cases to possess the power of repair and regeneration to a remarkable degree.

The calibre of the spinal canal is not usually lessened by the characteristic angular distortion of the back, although the weight and forward inclination of the trunk may force the softened tissues backward against the cord and thus increase the direct pressure; in fact paralysis is much more often associated with a slight or moderate kyphosis than with extreme deformity.

Frequency of Paralysis.—In 1,670 cases of Pott's disease recorded at the New York Orthopædic Dispensary, paralysis occurred in 218,[1] and in 445 cases in the private practice of Dr. C. F. Taylor,[2] 59 cases of paralysis were observed. Thus in a total of 2,015 cases of Pott's disease there were 279 cases of paralysis or 13.7 per cent.

[1] Myers, Trans. Am. Ortho. Ass'n, Vol. III., 1891, p. 209.
[2] Taylor and Lovett, N. Y. Med. Record, June 19, 1896.

This proportion is much larger than the normal however, for many of the patients were taken to the specialist or to the special hospital because of the paralysis, as in 40 of Taylor's and in 133 of the Dispensary cases. If these be excluded, the percentage of paralysis occurring in those actually under treatment is reduced to 5.6 per cent. This percentage corresponds very closely to that of Dollinger,[1] viz.: 41 cases of paralysis in 700 cases of Pott's disease under treatment (5.8 per cent.), and it may be accepted as representing the average liability to paralysis among those who have received treatment for Pott's disease, the percentage being much higher in neglected cases.

The Liability to Paralysis in Disease of the Different Regions of the Spine.—The liability to paralysis is very much greater in disease of certain regions of the spine than in others.

Thus 105 of the 209 cases in Myers's list, in which the situation of the disease was recorded, complicated disease of the dorsal region above

FIG. 57.

Pott's paraplegia before the stage of deformity. The same patient is shown in Fig. 47.

the eighth vertebra. Of the remainder, in 16 the disease was of the cervical region; in 12 of the cervico-dorsal and in 59 of the lower dorsal and dorso-lumbar regions.

37 of Taylor's 59 cases were caused by disease of the dorsal region; 8 occurred in the cervical and cervico-dorsal, and 11 in the dorso-lumbar and lumbar regions.

26 of the total of 41 cases recorded by Dollinger were caused by disease of the third to the seventh dorsal vertebræ inclusive, or about 23 per cent. of the cases in which this region was involved.

In 132 cases of paraplegia reported by Gibney,[2] not one complicated disease of the lumbar region; nearly all were caused by compression in the middle or upper dorsal segment.

These statistics show that the upper and middle dorsal section is the point of greatest liability to paralysis, a fact that is explained possibly by the smaller size of the canal at this point, and by the difficulty in assuring complete fixation at the seat of disease. In this

[1] Loc. cit.

[2] Journal of Nervous and Mental Diseases, Jan. 5, 1897

region it may be estimated that 15 per cent. of the cases of Pott's disease will be complicated by paralysis before cure is established.

Prognosis.—In properly treated cases the prognosis is very favorable. The final results of 47 of the 59 cases of paraplegia in Taylor's practice were ascertained. Of these 39 recovered completely, 5 died of intercurrent disease while apparently recovering and in 3 the recovery was partial.

Of the hospital cases recorded by Myers, 3 per cent. died of intercurrent disease. The final results could be ascertained in but 55 per cent. of the patients who remained under treatment. All of these recovered.

In 74 cases of paraplegia treated by Gibney,[1] 45 were cured, 12 improved, 8 unimproved and 9 died. Thus 77 per cent. were cured or improved; and in a similar series of 40 cases reported by Shaffer 80 per cent. were cured and but 10 per cent. of the remainder were considered as hopeless cases.

Recurrence of paralysis after recovery is not infrequent; in 18 cases such recurrences from one to four times are recorded by Myers, and seven successive attacks of paralysis were observed in a patient under treatment at the Hospital for Ruptured and Crippled.

The relapses depend upon the situation or upon the renewed activity of the disease and are often explained by the neglect of protective treatment.

Duration.—In exceptional cases the paralysis appears to be caused by temporary pressure or simply to disturbance of the circulation of the cord, due possibly to the pressure of the superincumbent weight upon the softened and diseased tissues, as it disappears almost immediately when the spine is straightened and supported. Usually the paralysis remains for several months, not infrequently it lasts a year, and partial or even complete recovery is possible after a much longer time. Recovery from the paralysis depends upon the course of the disease of which it is a symptom, upon the absorption and organization of the tuberculous granulations that press upon the cord and upon the regenerative changes in its structure, if it has been implicated in the disease.

Time of Onset.—In exceptional cases the paralysis may precede deformity and it may be the first symptom that attracts attention to the disease. In 14 of 74 cases reported by Gibney, the paralysis was present when the bone disease was recognized, but it is probable that the primary disease had existed for several months before the appearance of the paralysis. Usually it is a comparatively late symptom, appearing after the stage of deformity and more often from 6 to 12 months after the recognition of the disease, but its appearance may be deferred until long after apparent cure.

Symptoms of Pott's Paraplegia.—The most marked effect of the pressure on the cord is the interference with its conductivity; thus the reflex centers situated below the point of constriction, relieved from the inhibition of the brain, become over-active, while voluntary motion of the parts below the constriction is difficult or impossible.

[1] Loc. cit.

The pressure of the diseased products is more directly upon the antero-lateral columns so that motion is much more often primarily affected than is sensation.

The early symptoms of Pott's paraplegia, as noticed by the patient or his friends, are weakness, awkwardness and a stumbling, shambling gait. The symptoms usually increase rapidly until paralysis of motion is complete. At this stage the patella tendon reflex is increased and ankle clonus is often present. As a rule both legs are affected in equal degree, but occasionally paralysis of one leg may precede that in the other; or in the stage of recovery power may return more rapidly in one limb than in the other. The limbs in the early stage of the paralysis may appear limp and powerless, but when the patient is moved or when the reflexes are stimulated the peculiar spastic rigidity or stiffness appears.

As a rule the rigidity increases with the duration of the disease and spastic contractions are often present; thus the thighs may be approximated, the knees flexed and the feet extended. Persistent contractions indicate, as a rule, permanent damage to the cord, and at this stage complete recovery is infrequent.

Sensation is retained in the mild cases, but in the more severe or prolonged cases it may be impaired or lost. Sensation was retained throughout in 24 of the 40 cases reported by Shaffer.

In the cases of partial paralysis, control of the bladder may be retained, but usually there is incontinence. As the bladder fills the reflex center is excited and it empties itself. The control of the sphincter ani is less often or less noticeably affected.

As the paralysis is the result of more active or of advancing disease, its onset may be preceded by an increase of pain; thus greater discomfort attended by an increase in the patella tendon reflex may be considered as an indication for enforced rest of the individual, although increased activity of the reflexes is not uncommon during the more active stage of the disease without apparent involvement of the spinal cord. When paralysis occurs in patients who are under treatment for Pott's disease the onset is not, as a rule, attended by noticeable or unusual pain, the reflected pain or nerve root symptoms, so often described, do not differ from the ordinary pain of Pott's disease; in many cases such symptoms are lacking, nor is pain usually complained of after the paralysis has developed.

The extent of the paralysis depends upon the situation of the disease. In exceptional cases, when the cervical cord is implicated, both the arms and legs may be paralyzed; this occurred in seven of the cases reported by Myers. As a rule, however, the paralysis is a complication of disease of the dorsal region, above the reflex centers in the lumbar enlargement of the cord, but below the nerve supply of the upper extremities. If the disease were at a lower point, for example in the dorso-lumbar section, so that these reflex centers themselves were directly implicated, then reflex activity would not be increased, and intermittent incontinence would be replaced by constant dribbling of urine; or if the cauda equina alone were implicated in disease of

the lumbo-sacral region, the symptoms would be those of neuritis, pain, numbness and weakness in the area supplied by the affected nerves.

In ordinary cases, the nutrition of the limbs is not greatly affected, nor do the contractions become permanent, but when the paralysis is prolonged, and when sensation is lost, the muscles waste, the circulation is impaired, and fixed distortions usually appear. But even in the more prolonged and severe forms of paralysis, occurring in childhood, bedsores are rarely seen.

Treatment.—The treatment of the paralysis is included in the treatment of the disease of which it is a symptom, except that even greater care should be exercised to assure fixation of the spine.

Rest in the horizontal position on the Bradford frame is indicated, and over-extension of the spine should be aimed at by bending the side bars in the manner described. Direct traction by the weight and pulley should be used if the disease is in the upper dorsal or cervical regions. The back brace, in addition to the frame, assures additional fixation, and should be used if possible. If, however, the brace has been worn before the paralysis, its shape must be modified to accommodate the change in the outline of the spine, induced by recumbency and extension.

Manipulation or massage of the limbs is contraindicated because it stimulates the reflex centers. If constant contractions of the muscles are present, the deformity may be reduced by traction applied in the ordinary manner (Fig. 28), or a fixation brace may be worn. The spasmodic contractions are often painful, and if the paralysis is complicated by tuberculous joint disease, extension and fixation combined may be indicated to relieve the joint from the injury of involuntary motion.

Counter-irritation at the seat of disease was by Pott considered of the greatest value, and the application of the actual cautery from time to time, about the kyphosis, seems in certain cases to exert a favorable influence on the underlying disease.

Electricity, particularly galvinism, has been used and it is of some service in preserving the nutrition of the limbs. Its value in a case must be judged by its effect.

Of the internal remedies the most useful seems to be iodide of potassium. It is supposed to act upon the tuberculous granulation tissue as upon the products of syphilitic disease. A convenient method of administration is a solution of which one drop represents one grain of the drug. This is given in milk or in Vichy water beginning with five drops three times daily and increasing the dose a drop each day until the point of toleration is reached.

The first indication of improvement is usually lessening of the muscular rigidity; then the ability to move a toe is regained, after which recovery follows quickly. At this stage massage of the limbs may be employed with advantage. The exaggerated reflexes may persist long after recovery, in fact, as has been stated, this symptom is not uncommon among patients suffering from dorsal Pott's disease who have never been paralyzed.

The Operative Treatment.—The operation of laminectomy was at one time in favor but it has now been practically abandoned, as a treatment of routine at least, for the paraplegia of Pott's disease; because it has been proved that recovery, if somewhat long deferred, is the rule without operation while the direct death rate of the operation is at least 20 per cent. In 134 cases collected by Rhein[1] the immediate mortality (those dying within a month after the operation) was 36 per cent.

Laminectomy is an incomplete operation in the sense that the disease of the bone is not removed, and recurrence of paralysis and extension of the disease are not infrequent after a successful immediate result. It should be reserved for those cases in which after a thorough and prolonged trial of ordinary methods the condition does not improve. Eighteen months has been suggested as the proper time in which to test conservative treatment. The operation may be indicated also if the symptoms, in spite of treatment, increase in severity, and when there is evidence that the integrity of the cord is threatened, or when the paralysis is of sudden onset, or when displacement of bone or pressure from an abscess seems probable as the exciting cause although in the latter instance the direct evacuation of the abscess by costo-transversectomy, as advocated by Ménard, would seem to be the more reasonable procedure. Occasionally the operation is performed as a forlorn hope in adults suffering from cystitis and bedsores.

The usual method in operating is as follows: A long incision is made parallel to and close by the side of the spinous processes. The muscles are drawn to one side, the spinous processes are cut through and drawn with the attached muscles to the opposite side. The laminæ at the seat of disease are then removed with the cutting forceps, exposing the dura mater. The tuberculous tissue is usually found upon the front or lateral surfaces of the canal, and its complete removal is often impossible. The shock of the operation is often marked so that it should be as rapid as possible, and loss of blood should be carefully guarded against. After the operation the spine should be supported by the brace or jacket until the disease is cured.

In several instances forcible correction of the spine (Calot's operation) relieved the pressure on the cord and rapid recovery followed. This indicates the importance of assuring over-extension of the spine whenever it is possible, but this should be attained by gradual, postural correction rather than by force.

Fortunately the great majority of cases of paraplegia from Pott's disease occur in childhood, and, as has been mentioned, the complications of later life, bedsores, cystitis and the like, are rarely troublesome. Such paralysis in the adult is more serious from every point of view. The principles of treatment are the same, but their application is more difficult and the prognosis is more doubtful.

Local Paralysis.—In certain cases the extension of the disease may involve the nerve roots at their exit from the spine. This may occur

[1] Willard, Journal of Nervous and Mental Diseases, May, 1897.

with, or independently of, the involvement of the cord. The symptoms are those of neuritis in the affected nerves. In extremely rare instances the pressure on the cord may cause hemiplegia.

The Duration of the Treatment of Pott's Disease.—The duration of the treatment must depend upon the extent and severity of the disease. It may be divided into two stages : one during which the disease is active, when absolute fixation is indicated, and a stage of recovery, during which supervision is required. During the first stage the destructive process may increase the absolute deformity ; during the later period of weakness the distortion may increase, simply because of the general inclination toward deformity and because of the weakness of the supporting muscles.

Tuberculosis of the spine is slow in its progress and recovery is often insecure. The course of the disease is shortest in the cervical region, but even here two years of brace treatment will probably be required, and in the lower region double this time, even in the milder type of cases. Active treatment should be continued as long as there is evidence of disease. The absence of the general symptoms of pain and weakness is of little value in determining the absolute cure if braces have been employed. Muscular spasm is of more value, since it usually persists as long as the disease is active ; the presence of pain on passive motion or muscular contraction or abscess would of course indicate the necessity of further treatment.

Direct palpation is of some value in determining the condition of the affected part. During the progressive stage careful, deep pressure over the spinous processes may show greater mobility of those involved in the disease. During the stage of repair and consolidation the mobility is replaced by rigidity. The appearance of the kyphosis has also some significance. In the early stage of the disease its area is not clearly defined, but when consolidation has taken place the extent of the disease is shown by the rigid vertebræ which stand out separated from the remainder of the spine by a well-marked sulcus which is much deeper below than above the kyphosis.

Even when the disease appears to be cured, *removal of support* should be gradual and tentative ; the jacket is replaced by the corset, the brace by a lighter appliance, then support is removed at night, later for part of the day and at last, after many months, it is discarded.

Such careful supervision must be continued for a much longer time if the best ultimate result is to be attained, for as has been mentioned, one should guard against the secondary distortions, which may be due simply to weakness and to the unfavorable mechanical conditions induced by the primary deformity. If curvatures of the spine are so common among those whose backs may be supposed to be fairly normal, how much more likely is such secondary deformity to result when the back has been weakened by disease and by long disuse of the muscles.

This secondary increase of deformity is not so much to be feared after the cure of the disease in the lumbar region, because of the favorable attitude of erectness, nor is it likely to be marked after cure in

L. of C.

the cervical region of the spine; but in disease of the upper and middle dorsal region brace treatment must be continued long after the disease is cured, and supervision must be exercised until after the period of adolescence, if the increase of deformity is to be prevented.

Recurrence of Disease and Later Effects of Deformity.—The disease may recur after an interval of many years of apparent cure and such recurrences are sometimes accompanied by the formation of an abscess or by paralysis.

If recovery from Pott's disease has been complete and if deformity has been prevented, the condition of the patient is to all intents normal, but if the course of the disease has been prolonged and if the deformity is great, his condition is abnormal; he is unfitted for ordinary occupations, and comparative comfort is assured only by constant care. Such individuals are likely to suffer from neuralgic pain about the weakened spine on over-exertion or whenever the general condition is depressed from any cause. In such cases the use of some form of light corset adds to the comfort of the patient.

Secondary Deformities.—While the patient is under treatment for Pott's disease one should be on the alert to prevent other deformities that may follow the general weakness and restriction of normal functions. One of these is the *weak foot*, sometimes called weak ankle or flat foot, and with it is often associated a moderate degree of knock knee. This may be prevented by the use of a Waukenphast shoe, of which the heel and sole should be raised one-fourth of an inch on the inner side.

Recapitulation.—Fixation on the portable frame is the treatment of choice in infancy and early childhood, without regard to the situation of the disease. Ambulatory treatment is the treatment of selection in later childhood, adolescence and adult life.

Horizontal fixation is by far the most effective treatment of the local disease and deformity; it is therefore the treatment that is held in reserve to meet emergencies, when symptoms are not relieved, when deformity is advancing and when complications are troublesome. The disadvantages of the treatment are evident although likely to be exaggerated. The young child fixed upon the frame may be carried about in the open air, but the older patient is moved about with more difficulty and is likely on this account to be deprived of the stimulation of outdoor life as well as of exercise.

Ambulatory treatment must always supplement that by recumbency, and in the great majority of cases it is the treatment of necessity and routine. Its efficiency will depend, in great measure, upon the careful regulation of the strain which the erect posture and the activity of the patient throws upon the weakened spine.

Of the relative merits of the supports that have been described it may be stated that the plaster jacket has the great advantage of cheapness; its use places the treatment in the hands of the surgeon, and in the middle region of the spine, it is equal to, and may even be superior to, the brace. The laced corset is not equal as a support to the solid jacket.

The back brace has a wider range of adaptability than the jacket. Its disadvantages are the original expense, the difficulty of accurate adjustment and the fact that it can be removed by the parents, who are inclined to neglect medical supervision, when the use of the apparatus has become familiar to them.

The jury mast, although a very useful appliance under certain circumstances, is inferior to the metallic head rest when accurate fixation or support is desired.

The complications of Pott's disease, abscess and paralysis, should be considered and treated as symptoms only, symptoms that may or may not require direct treatment according to the indications that have been described. Finally one should always bear in mind that the final cure of the disease depends upon the increase of the vital force; thus the importance of fostering and improving the general well-being of the patient cannot be too strongly urged.

Forcible Correction of the Deformity of Pott's Disease. Calot's Operation.—Forcible correction of the deformities of the spine was advocated by several of the ancient writers, notably by Hippocrates and by Paré, but in modern times, with the better understanding of the pathology of Pott's disease, the direct deformity that a patient presented when coming under treatment was supposed to be irremediable, since it represented actual destruction of bone.

In 1896 this method of forcible correction of deformity which had been revived by Chipault several years before[1] was popularized by Calot of Berck sur Mèr,[2] who claimed that it was particularly adapted to the treatment of the kyphosis of tuberculous disease. Originally he advocated the immediate correction of such deformity, although of long standing, even if chiseling through the anchylosed vertebræ and removal of the spinous processes were required, but operative treatment in this class of cases has now been practically abandoned.

At the eleventh Congress of French Surgeons at Paris in 1897 Calot outlined the operation as follows: In the recent cases the deformity was corrected by direct manual traction and by pressure on the kyphosis. The traction employed was estimated at 60 to 160 pounds, the pressure at 30 to 80 pounds, but in the more resistant type it was well to reduce the deformity gradually, at several sittings. Of 204 patients treated by this method, two died in two days, and three others of broncho-pneumonia several months after the operation. In one case partial paralysis appeared and in another an abscess was observed soon after the procedure.

Since Calot's original publication hundreds of operations have been performed with results not differing essentially from those that he reported. It has been demonstrated that the deformity of Pott's disease, in more recent cases, can be partly or entirely corrected by force in one or more sittings with but little danger to the patient.[3] If the

[1] Travaux de neurologie Chir., 1895, 1896, 1897.

[2] Archiv prov. de Chir., February, 1897. T. 6, n. 2.

[3] Bradford and Cotton (Boston Med. and Surg. Journal, September 20, 1900) have recently analyzed the literature of Calot's operation, viz:

disease is in the progressive stage, and if the operation is undertaken before adhesions and contractions have formed, the correction will be easy. If the disease is in the stage of repair, the correction will necessitate forcible separation of contracted tissues and the breaking up, it may be, of an actual anchylosis. If an abscess be present, whose coverings are adherent to the surrounding parts, the forcible correction may rupture its walls and allow the escape of the pus into the lung or pleural cavity. The more remote dangers are abscess or paralysis due to a direct extension of the local process, or a general dissemination of the tuberculous disease.

If the spine is straightened it is evident that there must be an actual separation of the diseased parts; the spine is, as it were, straightened on the hinge formed by the articulating surfaces of the transverse processes. (Fig. 4.) This is an attitude favorable to repair since compression and attrition can no longer aggravate the destructive process. If paralysis be present, induced in part by the compression of the softened tissues at the seat of disease, it may be relieved by the correction of the deformity. This point was illustrated in two cases at the Hospital for the Ruptured and Crippled by an immediate improvement and rapid recovery from paraplegia after the operation.

It must be borne in mind however that the operation is undertaken for the relief of deformity. It is certain that the spine can be straightened and that it can be retained for a time in the corrected position, but it is unlikely that the interval left between the upper and lower segments of the spine will be filled with new bone. This can only be decided by a study of final results many years after the operation.

There is, as a rule, an immediate recurrence of a certain amount of deformity because of the natural recoil toward the habitual posture, and because in many instances the straightening of the spine has been due to an obliteration of secondary curvature rather than to actual separation at the seat of disease, and finally even if the interval between the segments were filled with calcified tissue, such bone does not grow as it contains no epiphyses, consequently this irregularity must become more and more marked with the growth of the child. In other words although the effect of the destructive disease on the spine can be modified it cannot be entirely remedied even by the most successful operation.

The Selection of Cases for Forcible Correction.—The favorable cases are those in which the deformity is of comparatively short dura-

Six hundred and thirty-nine cases were performed by thirty-four operators. Time elapsed varied from a few days up to three years or more. Of the separate detailed cases in 7 more than one year had elapsed; in 35 more than six months.

Deaths reported from all causes, 25; various diseases, 5; general tuberculosis, 4; trauma of the operation and chloroform, 5; intercurrent disease, 7.

Immediate results: Respiratory embarrassment, 7; pain, 6; severe shock, 3.

Abscess present before operation, 19; ruptured, 4; benefited or absorbed, 6; appeared after operation, 2.

Paralysis present before operation, 23; relieved, 17; not relieved, 2; made worse, 1. Paralysis appeared after correction in 4.

Direct effect on deformity in 240 cases: Complete correction, 130; incomplete, 94.

Result in 77 cases: No relapse, 20; some relapse, 50; total relapse, 7.

tion, cases in which the adhesions and the accommodative changes in the soft parts are not sufficient to offer resistance to correction, and in which the internal organs have not been long displaced or compressed. Well-marked deformities of the middle and lower dorsal region are especially suitable for the operation.

The most unfavorable cases are those of fixed deformity, in which repair is progressing or is completed, and in which the organs and tissues of the body have been changed in shape and function to accommodate the new conditions.

As a rule deformity of the lumbar and of the cervical regions is not sufficient to require forcible correction.

The presence of an abscess in the posterior mediastinum or elsewhere if it be in the active or progressive stage should contraindicate the operation. On the other hand paralysis, which is most often a complication of diseases in the dorsal region, is not a contraindication.

The Operation.—As ordinarily performed the patient having been prepared as for the application of a plaster jacket is anæsthetized and is then suspended face downward in the horizontal position by five assistants who make moderate steady traction upon each extremity and upon the head while the surgeon, standing by the side of the patient, gently presses downward directly upon the kyphosis, which in the favorable cases, is gradually obliterated, the straightening of the spine being accompanied by the audible separation of adhesions.

The force employed, as stated by Calot, is traction of 60 to 160 pounds and pressure of from 30 to 80 pounds. As a rule the force is much less, and there is little danger from this source. Jones states that a traction force of nearly 600 pounds is required to dislocate the neck of a child two and one-half years of age; that five men pulling in the manner above described, with a force that soon tires, rarely exceed a traction force of 175 pounds.

If the correction is to be completed at the first attempt the spine is over-extended and while it is held in this attitude a plaster jacket is applied. If the disease is of the middle of the back, the head need not be included, but it is better to fix and draw the shoulders backward by including them in the plaster. Great care should be taken to prevent excoriation. Very long, thick, wide pads should be placed on either side of the spinous processes; the iliac crests and other prominences should be protected and a so-called dinner pad should be inserted below the sternum, which may, when removed, allow additional room for respiration. This is of great importance if the patient has not worn a plaster jacket before the operation. If the disease is of the upper dorsal region, the head must be included in the bandage. Calot suspends the anæsthetized patient as in the ordinary manner for applying a jacket; other surgeons suspend the patient with the head downward during the application of this part of the bandage, but with a little care the head support may be applied with the patient in the horizontal position.

The hair should be cut closely and protected from the plaster by a

well-fitting skull cap. The bandage is then continued over the head and neck as in the illustration. (Fig. 49.) A strip of malleable steel, bent to fit the occiput, may be incorporated in the bandage to give it sufficient strength.

Many surgeons employ other supports than the plaster. One of the best forms of apparatus is the double Thomas brace used by Jones. The stretcher splint may be used also.

In properly selected cases there is little shock after the operation, but if the change in the contour of the spine has been considerable, respiration may be somewhat embarrassed by the plaster jacket. In such cases it must be split through the front and separated. In all cases it is well to cut through the plaster at points where direct pressure is likely to be exerted, in order to guard against excoriations.

As a rule the operation should be followed by prolonged rest on the back 3 to 6 months or longer to allow for adaptation to the new position and for consolidation, but as far as symptoms are concerned the patients may be up and about as usual in a few days if the spine can be held properly by the plaster jacket, as has been the case with many of the patients at the Hospital for Ruptured and Crippled.

As has been stated there is a marked tendency toward recurrence of deformity. On this account some surgeons advocate wiring the spinous processes to one another as originally suggested by Hadra and practiced by Chipault. The operation is a simple one, but its efficacy is doubtful.

In cases in which the deformity is of the resistant type it is well to divide the rectification into several sittings at intervals of a week or more. In many instances anæsthesia is not required after the first operation; for traction and even the forcible pressure at the seat of disease do not appear to cause particular discomfort.

Gradual Correction of Deformity.

Corrective force may be applied also by methods that do not deserve the name operation. For example a certain amount of traction and pressure may be employed with advantage during the application of the plaster jacket in the ordinary manner if the cases are properly selected.

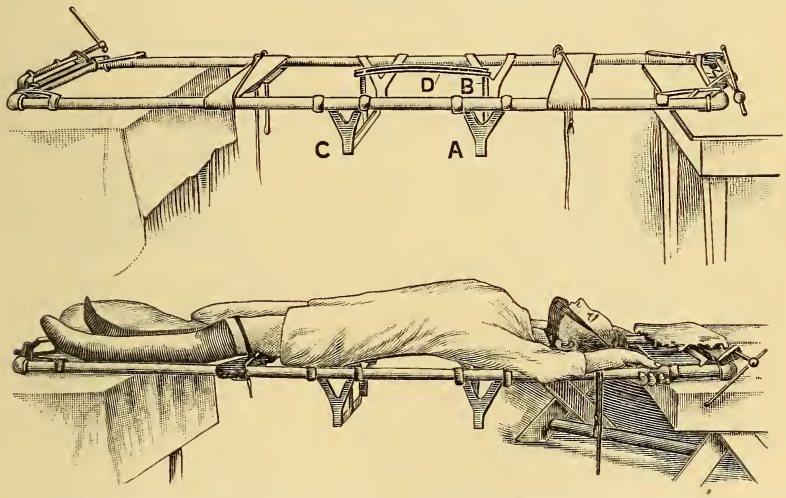
But the most efficacious method of gradual or non-violent correction is that employed by Goldthwait[1] by horizontal traction and leverage. This method is described by him as follows:

"The apparatus which has been used consists of a strong gas-pipe frame, six feet long by two feet wide. Suspended from this is a bar (*a*), in the center of which is a vertical rod (*b*), forked at the top and long enough to reach to the level of the frame. This crossbar is simply suspended from the frame so that its position can be changed as desired. Below this is another crossbar (*c*), which rests on the frame and can also be adjusted as to position. Upon this latter piece (*c*) and upon the fork of the rod (*b*) rest two malleable steel bars (*d*), about eighteen inches long. These rest in grooves one inch apart, and

[1] Trans. Am. Ortho. Ass'n, Vol. XI., p. 95.

should be bent to partly conform with the lumbar curve of the spine, after which they are heavily padded with felt and the patient laid upon them. The upper end of the bars (*d*) should just rest upon the fork, not projecting over, and when the patient is in position the rod should be one inch above the apex of the deformity. The buttocks rest upon the crossbar (*c*), and the legs are supported by one or more heavy webbing straps which can be tightened or loosened at will. No support whatever is given the upper part of the body, except that the head is steadied by the surgeon with the hand until a satisfactory amount of correction has been accomplished, and then a strap similar to those used below gives the support so that the operator's hand is free. If traction is desirable, it can be applied by means of a windlass which is attached to each end of the frame. This makes it pos-

FIG. 58.



The plaster jacket applied in supine posture by means of the Metzger-Goldthwait apparatus.

sible to obtain much more definite and steady traction than would be possible with assistants, but its use has not been found necessary in the majority of the cases, simple over-extension of the spine accomplishing the same results.

When the maximum over-extension that is desirable is obtained, the strap under the head is fastened and the patient allowed to lie in this position while the jacket is applied. In applying this the iliac crests should be generously padded with heavy felt and a similar pad should be placed over the upper part of the sternum so that the jacket can be carried high up to prevent the upper part of the body with the shoulders from drooping forward. In the cases with disease in the upper dorsal region the jacket should be moulded about the anterior part of the neck so that erect position of the head is necessary. The forked rod (*b*) is easily avoided by a few figure-of-eight turns of the

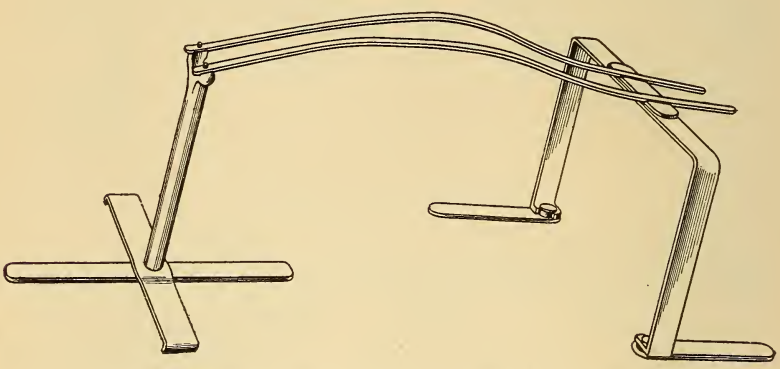
bandage, so that when the plaster has set the patient can easily be lifted off, and as the rod (*b*) should be placed one inch above the apex of the deformity this weak spot in the jacket is not objectionable.

When the patient is taken off the frame the two rods (*d*) are slipped out from below leaving the padding in place.

As a matter of experience it has been found necessary to practically always cut a small window over the point of greatest deformity as otherwise when the body settles down, as is inevitable, a slough will form even though a liberal amount of padding has been used. This procedure is repeated from time to time until the best possible attitude has been obtained. This method originally devised as a modification of the Calot method of forcible correction of deformity is now employed in the routine application of the plaster jacket. For this purpose Goldthwait uses a portable frame as shown in the illustration.

It may be stated of forcible correction of the spine (Calot's opera-

Fig. 59.



Goldthwait's portable frame for applying the plaster jacket. (See Fig. 46.)

tion), that it is in no sense curative; that although it has been proved that the back can be straightened, in many instances with ease and in most cases with but little danger, yet the retention of the spine in the corrected position is difficult, and a certain immediate recoil toward deformity is the rule. Even if the interval between the two segments be filled with new bone, the growth of the spine at this point being checked, an increase of the irregularity with advancing years may be expected. In fact, correction of deformity is in no sense a substitute for prevention. The ease with which correction may be made in early cases, emphasizes the importance of rest on the back, in the over-extended attitude, as a means of correcting deformity, in cases in which operative intervention seems to be contra-indicated.

The final judgment can not be passed upon this procedure for many years; it has rapidly lost favor during the past year, partly because of recurrence of deformity, and partly because experience has shown that the same degree of rectification may be attained by milder methods.

CHAPTER II.

NON-TUBERCULOUS AFFECTIONS OF THE SPINE.

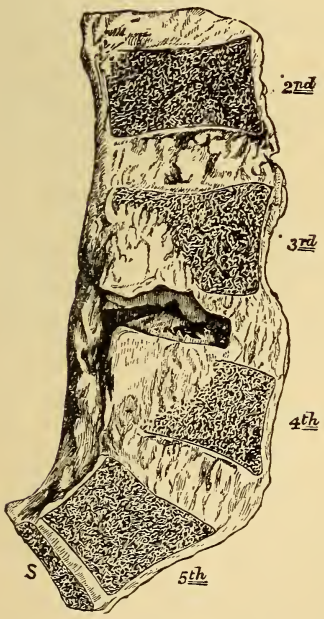
Syphilis.

This disease, in the inherited or in the later stages of the acquired form, may affect the bones of the spine and cause local deformity and symptoms that cannot be distinguished from those of Pott's disease.

Diagnosis.—As compared with tuberculosis, it is a rare disease of the spine. Its manifestations are likely to be general in character, the deformity of the spine being but one of many evidences of disease.

If syphilis were limited to the spine and simulated the symptoms and the deformity of Pott's disease, it would demand the same local treatment. Specific remedies should always be administered when one has reason to suspect its presence, as in the treatment of syphilitic disease of other parts.

Fig. 60.



Vertical antero-posterior section of lumbar spine showing deposit of gumma in the posterior part of the third and fourth vertebræ (after Fournier).

Malignant Disease of the Spine.

Malignant disease of the spine is a rare affection, particularly so in childhood. Sarcoma is more common than carcinoma, which, when it affects the spine, is almost always secondary to a primary tumor elsewhere, as of the breast.

Diagnosis.—Malignant disease differs from tuberculosis of the spine in that its symptoms are usually more severe; the pain is usually persistent and it is not relieved by support or recumbency, as is that of Pott's disease. The constitutional symptoms are more marked and the steady progress of the disease toward a fatal termination is soon apparent. Locally, the angular deformity is usually slight and it may be absent. Not infrequently the tumor may be palpated through the abdominal wall. Paralysis is a frequent, and often an early, symptom.

As has been stated, *carcinoma* is almost always secondary, but *sar-*

coma of the spine may be the primary focus of disease; in such cases diagnosis in the early stage is often impossible.

Malignant disease of the spine is a fatal affection and the treatment can be but palliative.

Acute Osteomyelitis of the Spine.

Infectious osteomyelitis of the spine is uncommon, but 41 cases are recorded in literature.[1]

Symptoms.—Its symptoms are similar to those of acute infectious processes elsewhere and are characterized by sudden onset, with pain, fever and constitutional depression. There is local pain and tenderness about the spine. Abscess quickly forms; and paralysis, from the rapid extension of the disease is a common complication.[2] The symptoms due to pyogenic infection and to deep-seated abscess, are often pyæmic in character, and necrosis of the affected vertebral bodies may result in the formation of large sequestra. The death rate is about 50 per cent.

Treatment.—The treatment consists in the immediate evacuation and drainage of the abscess, the removal of the necrosed bone if possible, and in supporting the spine during the subsequent stage of weakness.

A more localized and more chronic form of osteomyelitis may occur, but it is practically impossible to distinguish its symptoms from those of tuberculous disease.

Actinomycosis of the Spine.

Actinomycosis of the spine is an extremely rare disease and need only be mentioned as a possibility. Its diagnosis may be made by the microscopic examination of the discharge from the sinuses that almost always form early in the course of the disease.

Injury of the Spine.

Severe sprains or fractures may simulate disease very closely and in some instances, particularly injury of the cervical region, diagnosis is practically impossible until after treatment by support and fixation has been applied; when, as a rule, if disease be absent, the symptoms, even though of long standing, quickly subside.

Fracture of the spine in the middle region may result in angular deformity, and when proper support has been neglected, symptoms of pain and weakness, similar to those of Pott's disease, may persist indefinitely.

Sudden forcible compression of one or more of the vertebral bodies without displacement and without severe immediate symptoms, other than the slight deformity, may be the result of injury, especially falls

[1] Hahn, Beiträge zur klin. Chir., Bd. XXV., H. 1, 1899.
[2] Muller, Deutsche Zeits. für Chir., Bd. 41.

from a height. These cases are not uncommon and are usually mistaken for Pott's disease.

Diagnosis.—The diagnosis should be made clear by the history.

Treatment.—In all such cases, and whenever weakness of the spine persists, and when motion causes pain, a support should be applied. Fracture of the spine should be treated as is fracture elsewhere, by reposition of the fragments, if possible or practicable, and by support, until the integrity of the parts has been reëstablished.

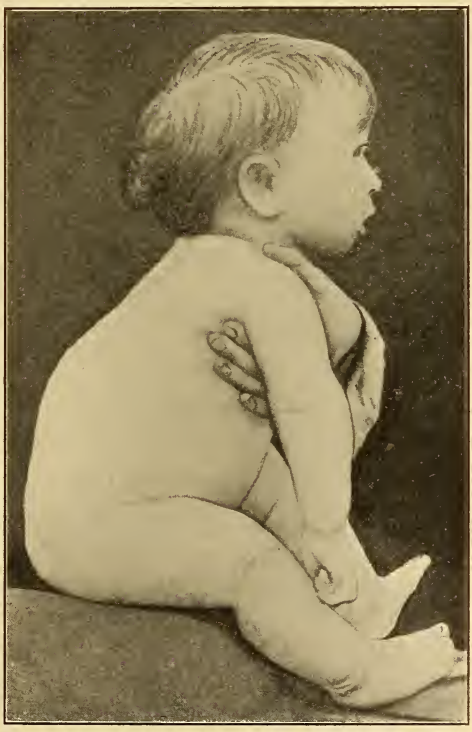
Traumatic Spondylitis.

Kummell[1] has described a form of rarefying ostitis of the spine of non-tuberculous origin, apparently caused by injury. It is characterized by symptoms of pain and weakness referred to the back, and by pronounced rounded kyphosis of the dorsal region. Motor disturbances of the lower extremities are frequent. The treatment is similar to that of Pott's disease. The nature of the affection, if it be a distinct variety of disease, is doubtful.

The Rhachitic Spine.

The rhachitic spine has been described in the consideration of the differential diagnosis of Pott's disease (p. 45). It most often develops during the first or second year of life, in children who sit the greater part of the time. It is, in fact, simply an exaggeration of the contour which is normal in the sitting posture; the typical rhachitic kyphosis is thus a rounded projection of the lower region of the spine, which is more or less rigid according to its duration. If the deformity is extreme, there is often a compensatory backward inclination of the head which may be exaggerated by contraction of the posterior group of muscles, "cervical opisthotonos."

FIG. 61.



Rhachitic kyphosis.

[1] Kummell, Deutsche med. Wochens., 1895, N. 11.

Treatment.—Aside from the constitutional treatment of the rhachitic condition, and from the measures that should be employed to improve the nutrition of the muscles in general, the indications are to overcome the rigidity and the limitation of motion in the spine; to support it, if necessary, during the stage of weakness; and to remove, if possible, the predisposing causes.

The correction of the deformity may be accomplished by massage, and by direct manipulation of the spine. The child is placed, face downward, on a table; one hand is applied over the projection, and with the other the legs are raised to throw the spine into a position of over-extension. This stretching is performed slowly and carefully over and over again at morning and night, and the manipulation is followed by thorough massage of the muscles. If the deformity is marked and if the general rhachitic process is still active, the infant may be kept for several months in the recumbent posture, on the frame or similar support.

In older subjects some form of light back brace may be sufficient in connection with the massage, and systematic correction of the deformity.

The Natural Cure.—It may be stated that the rhachitic spine is to a certain extent corrected when the erect posture is assumed, by the inclination of the pelvis and accompanying lordosis. This natural cure is however often rather a distribution of deformity than a cure, for the upper part of the projection may remain as an exaggeration of the normal dorsal kyphosis balanced by an exaggerated lordosis, "*the rhachitic attitude.*" And in other instances the persistence of the lumbar kyphosis may induce a compensatory flattening of the normal dorsal kyphosis. Thus rhachitis may cause the so-called *flat back*, as well.

PAINFUL AFFECTIONS OF THE SPINE NOT ATTENDED BY ANGULAR DEFORMITY.

Infectious Disease of the Coverings or Articulations of the Spine. "The Typhoid Spine." (Gibney.)

During the course of, or during convalescence from, typhoid fever, and occasionally after apparent recovery from the disease, symptoms of pain, weakness and stiffness of the back may appear. These are caused apparently by secondary infection of the fibrous coverings and attachments of the spine, similar to the more common, but more severe, forms of periostitis of the tibia or other bones, from the same cause. There is usually pain on motion and pain on pressure over the affected vertebræ.

Diagnosis.—The diagnosis is usually made clear by the history of the disease of which it is a complication.

Treatment.—The treatment should be symptomatic. During the active stage, if pain is severe, the patient should be kept in the recumbent position and opiates may be administered if necessary. Locally,

the application of the Paquelin cautery is of service. As soon as is practicable a back brace should be applied, which may be worn until the symptoms have subsided. Recovery may be predicted although a certain amount of restriction of motion may persist.

Symptoms resembling these may follow other forms of contagious disease, notably scarlet fever, but as a rule they are much less persistent and severe.

Gonorrhœal Rheumatism of the Spine.

"Gonorrhœal rheumatism" of the spine is rare. Its symptoms resemble those of the typhoid spine. Anchylosis is, however, more common as a result; in fact infection of this character is supposed to be one of the causes of spondylitis deformans.

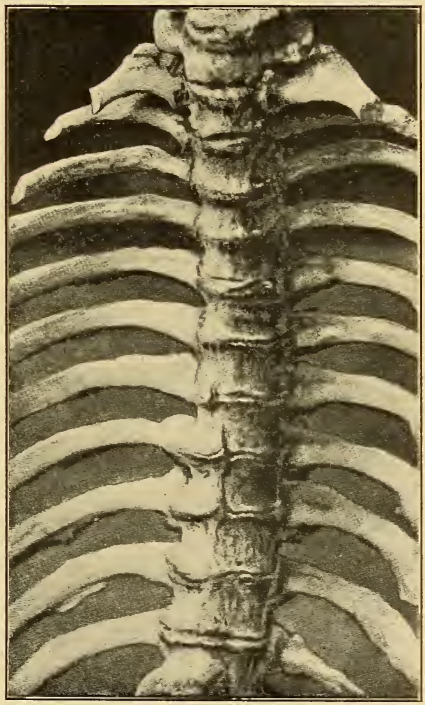
Locally massage, and support to prevent deformity, are indicated.

Arthritis of the Spine.

The smaller joints of the occipito-axoid region are sometimes affected by what appears to be a form of acute infectious arthritis similar in symptoms to acute rheumatism of this region but strictly localized. It may follow tonsilitis, diphtheria or other contagious disease. It may be distinguished from tuberculous disease by its acute onset and from acute torticollis by the fact that all motions are restricted.

Treatment.—The treatment consists in support during the acute stage followed by massage and manipulation to overcome the subsequent stiffness.

FIG. 62.



Spondylitis deformans. (GOLDTHWAIT.)

Spondylitis Deformans.

Synonyms.—Osteo-arthritis of the Spine — Rheumatism of the Spine—Spondylose Rhizomélique—Stiffness of the Vertebral Column.

Spondylitis deformans is an inflammatory affection of the spine terminating in ankylosis and deformity.

Pathology.—The disease is apparently a chronic inflammation which affects primarily the ligaments and the periosteal coverings of

the spine, a form of ossifying periostitis which binds the vertebræ firmly to one another. (Fig. 62.) It may begin on the lateral or on the anterior aspect of the spine; it may be limited to a particular region, but in most instances it involves the entire spine and often the articulations of the ribs as well. The intervertebral discs atrophy, but in some instances the margins of the cartilages proliferate and become ossified in a manner characteristic of osteo-arthritis of the joints.

Fig. 63.

Spondylitis deformans in a child.

Under the general term of spondylitis deformans are included, in all probability, several varieties of disease; for example:

1. The anchylosis of the spine may be simply a part of a general rheumatoid arthritis — Rheumatoid Arthritis of the Spine.

2. The spine may be involved together with one or more of the adjacent joints which show the characteristic symptoms of the hypertrophic form of rheumatoid arthritis. Osteo-arthritis of the Spine. This form has been designated by Marie as Spondylose Rhizomélique, spondylos-spine, rhizo-root, melos-extremity, signifying a disease of the spine together with the adjoining "root" joints.[1]

3. The disease may be limited to the spine and in such cases it appears to be entirely distinct from rheumatoid arthritis. It may follow acute rheumatism, it may be induced apparently by gonorrhœa, or by other forms of infection. It may begin acutely like inflammatory rheumatism or it may be chronic in character and progress slowly.[2]

Symptoms.—In the ordinary cases there is usually an acute onset from which the patient dates the beginning of his trouble, followed by a gradually increasing stiffness of the spine and accompanying deformity. The patient complains of stiffness, weakness, pain in the loins and of pain radiating forward along the ribs. Sometimes symptoms of weakness in the limbs, headache, nervousness and the like are present, symptoms that may be explained in part by the inflammatory

[1] Marie, Revue de Méd., Vol. 18, 1898.

[2] Bechterew, Neurol. Centb., Vol. II., p. 426. Senator, Berlin. klin. Wochen., Nov. 20, 1897.

process and by implication of the nerve roots and in part by an accompanying neurasthenia. The direct symptoms are increased by jars which are exaggerated by the inelasticity of the spine. The disease is usually progressive and terminates finally in complete rigidity of the spine which is bent into a long kyphosis most marked in the upper dorsal region, the lumbar lordosis being obliterated in many instances. (Fig. 62.)

When the disease is limited to the spine and larger joints, the occipito-axoid articulations are not usually involved.

The types of the disease may be illustrated by a brief description of four cases recently under observation.

FIG. 64.

Extreme posterior curvature of the spine in adolescence, showing retraction of the abdomen.

CASE 1. *Chronic Rheumatoid Arthritis of the Spine.*—In this case, in a boy ten years of age, there was characteristic general rheumatoid arthritis that involved nearly every joint of the body. The entire spine, even including the occipito-axoid joints, was rigid and the head was fixed in an attitude of extreme torticollis.

CASE 2. *Osteo-arthritis of the Spine.* — "Spondylose Rhizomélique." A man forty-six years of age, after repeated attacks of so-called rheumatism involving the larger joints, became gradually disabled because of pain and stiffness of the back and because of his inability to stand erect. In this case there was complete anchylosis of the spine except of the small joints of the cervical region, and in addition the right thigh was flexed upon the body at such an angle that the patient could walk only with an exaggerated stoop. The joints of the feet were slightly involved also. No cause other than exposure to cold and dampness could be assigned. The symptoms were of two years' duration, periods of comfort alternating with disabling attacks of "rheumatism."

CASE 3. *Spondylitis Deformans.*—The spine of this patient, a man forty-six years of age, was absolutely anchylosed in the characteristic position. The occipito-axoid joints were not involved. Fourteen years before, he had suffered from a severe and prolonged attack of in-

flammatory rheumatism, affecting nearly every joint, but not the spine, and during a succeeding period of nine years he had been disabled several times from the same cause. Each illness was coincident with gonorrhœa. Five years before examination the rheumatism had involved the spine and since then he had suffered from persistent "lumbago." Gradually the stiffness of the spine had increased, but during this time he had been free from gonorrhœa and from rheumatism as well. The joints were normal in appearance and function. This patient suffers principally from nervousness and irritability; he is easily startled, he feels as if his forehead were clasped by a tight band. His direct symptoms are pain in the loins and pain radiating under the shoulder blades, increased by walking or by jars. His equilibrium is disturbed by the forward projection of the head and by the obliteration of the normal lordosis, so that he feels himself constantly inclined to fall forward, whether he is sitting or standing.

Case 4.—In another case very similar to this, in a man thirty years of age, the spine had become rigid in a few months. The patient ascribed the disease to sleeping out of doors. There was in this case coincident disease of the lungs.

Treatment.—The local treatment is symptomatic. The application of cautery adds to the patient's comfort, and self suspension at intervals may relieve the dragging sensation in the muscles. Rubber heels are of service in lessening the jar. A brace may be applied if the pain is aggravated by motion; it may also serve together with the avoidance of predisposing attitudes to prevent extreme deformity of the spine.

Kyphosis of Adolescents.—A form of extreme kyphosis accompanied by stiffness and discomfort is sometimes seen. It appears to be a static deformity induced by over-work, in rapidly growing adolescents. It can hardly be classified with spondylitis deformans, although there may be some difficulty in distinguishing between the two. (Fig. 61.)

Osteitis Deformans.

Synonym.—Paget's Disease.

Osteitis deformans is a general disease characterized by hypertrophy and softening of the bones. The deformity of the spine is similar to that of rheumatoid arthritis, but the rigidity of the spine is not as extreme. The disease is described elsewhere.

PAINFUL AFFECTIONS OF THE SPINE NOT ATTENDED BY RIGIDITY.

The Neurotic Spine.

The "neurotic" spine is much more common in adolescence and in adult life than in childhood, and it is much more often observed in females than in males. The subjects are usually of a nervous or neurasthenic type, although in certain instances the symptoms appear to be the direct result of injury.

Symptoms.—The patient usually complains of a dull pain in the back of the neck, or in the lumbar or sacral region, of a constant tired feeling, and, not infrequently, of sharp neuralgic pain localized about a certain point in the spine, often the vertebra prominens. The contour of the spine may be normal, but most often there is a well-marked tendency toward a forward droop, the curve of weakness. (Fig. 65.) One of the characteristics of the neurotic spine is the *extreme local tenderness*, or hyperæsthesia, of the skin at certain points along the spinous processes. Thus if one passes the finger gently along the spine, the patient will often shrink or cry out, because of the pain. As a rule there is no limitation of motion or muscular spasm. The pain is local, not referred to the terminations of the nerves; in fact the symptoms are, in great part, subjective and irregular in character as contrasted with those of Pott's disease which are objective and well defined.

Fig. 65.

The neurotic spine. Characteristic attitude.

Treatment.—The treatment of the neurotic spine must be general in character as indicated by the condition of the patient. Locally, a light back brace or a long steel corset reinforced with steel bands, combined with the application of the cautery, is useful as a preliminary treatment. Later, massage and exercises may be employed. Complete recovery is usually long delayed.

The Hysterical Spine.

The hysterical spine is considered usually as synonymous with the neurotic spine, but as there are many individuals who suffer from sensitive spines who are not hysterical, it would seem proper to limit the latter term to the hysterical class.

Symptoms.—The symptoms do not differ particularly from those of the neurotic spine except that in certain instances actual deformity may be present; usually exaggerated lateral distortion, most marked in the lumbar region. Such cases are often supposed to be the effect

of injury, particularly of blows upon the back, but except as a possible cause of the appearance of a particular manifestation of the mental condition, injury could not explain the symptoms or the deformity.

Treatment.—The local treatment is similar to that of the neurotic spine.

Pain in the Lower Part of the Back.

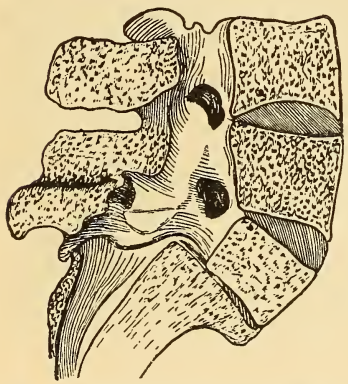
Pain in the lumbar region of the character of tire, weakness, or even of more extreme discomfort, is sometimes an accompaniment of disease or displacement of the pelvic or abdominal organs. Pain in this region is also a common symptom among overworked women. It is particularly troublesome when for any reason the lumbar lordosis is exaggerated temporarily, as during pregnancy, or permanently as a compensatory deformity for dorsal Pott's disease, or because of flexion of the thigh after hip disease.

As a result of strain or injury symptoms of pain and weakness in the lumbar region increased by sudden motions or over-exertion, may be persistent and disabling. Such cases are often classed as chronic lumbago and are probably the result of strain of the ligaments or deep muscles of the spine aggravated it may be, in certain instances, by rheumatism or other general affection of like character.

The **treatment** must be primarily directed to the condition of which the pain is a symptom.

When motion causes pain and when the symptoms are persistent, as in the lumbago type of cases, support in the form of a back brace, is indicated, the Knight brace or plaster corset being convenient forms. During the more acute stage the application of the cautery and the support of intersecting strips of adhesive plaster, covering a wide area, will often relieve the pain. Later, massage, electricity and the like may be of service.

FIG. 66.



Small pelvis of Prague (median section). Instance of slight forward displacement of fifth lumbar vertebra. (NEUGEBAUER.)

Spondylolisthesis.

Spondylolisthesis is a deformity in which the body of one of the lower lumbar vertebræ, most often the fifth, is displaced forward and downward. (Fig. 66.) The displacement is peculiar in that the spinous process may remain in its normal position, while the laminæ become elongated or separated from the displaced body. The condition was first described by Killian in 1854 and it was very thoroughly investigated by Neugebauer [1] in 1890.

The supposed causes are congenital malformation, injury and pos-

[1] Lovett, Trans. Am. Ortho. Ass'n, Vol. X., p. 22.

sibly disease of the lumbo-sacral articulation. Lane states that slighter degrees of the deformity are often observed among laborers. The effect of the displacement is to exaggerate the *lumbar lordosis* and to increase the prominence of the sacrum and of the iliac crests. The deformity is most often seen in women in whom it causes, in many instances, no particular symptoms, in fact its chief interest lies in its effect upon child-birth. As a rule, however, as has been stated in the preceding section, an increase of the lumbar lordosis is usually attended by a certain degree of discomfort and pain.

Lovett[1] has described a case in which the deformity was the result of direct injury. The patient, a young man, was successfully treated by a plaster jacket. Such cases, and those in which displacement is the result of disease, may require orthopædic treatment by braces or other support, for the relief of pain and for the prevention of further deformity.

Deformity Secondary to Sciatica.

Synonym.—Sciatic Scoliosis.

Severe sciatica often induces a change in the attitude and contour of the spine that may become a permanent deformity if its cause persists. As a rule the patient habitually inclines the body away from the painful part, in order to relieve the leg from weight, and bends the body slightly forward and abducts the limb to relax the tension on the sensitive nerve or plexus of nerves. Thus the pelvis on the affected side projects, there is a lateral lumbar convexity toward the opposite side, and often the normal lumbar lordosis is lessened or lost so that the final result may be a persistent lateral curvature, together with a change in the antero-posterior contour of the spine. (Fig. 66.) If the sciatica is a symptom of a more widespread neuritis, muscular weakness and muscular spasm may cause variations in the typical attitude, but this is unusual.

It must be borne in mind that disease of the lumbar spine, or of the pelvic bones or joints, or disease of the adjacent organs or parts may set up sciatica ; thus the cause of the pain should be carefully sought for.

Aside from the direct treatment of sciatica, support for the spine, preferably a light corset, may be indicated, if motion aggravates the pain or if the deformity persists.

Neuritis in other regions of the spine may cause symptoms of reflected pain and local sensitiveness. These symptoms are increased by motion, and a certain amount of local deformity, similar in character to that due to sciatica, may be present.

The **treatment** is similar to that indicated in the former affection.

Sacro-Iliac Disease.

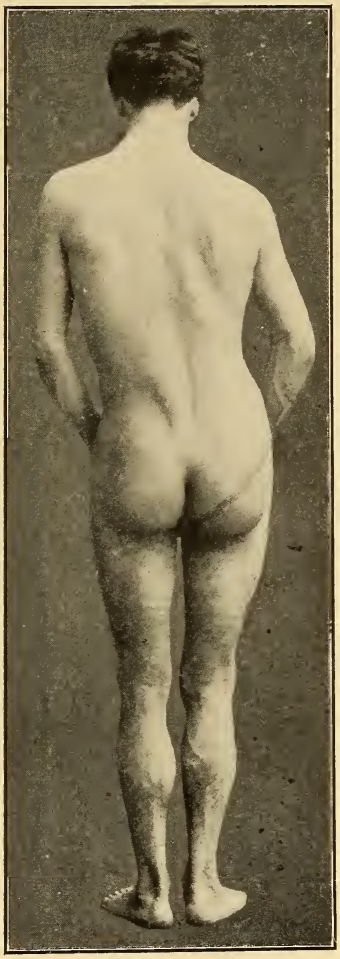
Tuberculous disease of the sacro-iliac articulation is a rare affection, and extremely so in childhood.

Symptoms.—The symptoms are pain, weakness, limp and change in attitude. The pain is referred to the side of the pelvis or radi-

[1] Trans. Am. Ortho. Ass'n, Vol. X.

ates over the buttock or thigh. It is increased by jars, by turning the body suddenly, sometimes by coughing or laughing; and a peculiar feeling of insecurity and weakness is sometimes complained of. As a rule the body is inclined toward the sound limb, thus the pelvis is lowered on the affected side and the leg seems longer than its fellow. In the early stage of the disease there is no deformity of the limb, but if a pelvic abscess forms, the thigh may become flexed. Locally, there may be sensitiveness to pressure on the articulation, and swelling in the neighborhood of the disease, although this is usually a late symptom. Pain is induced by lateral pressure on the pelvis or by any manipulation that disturbs the articulation.

FIG. 67.



Deformity caused by persistent sciatica of the right side. This attitude is similar to that symptomatic of sacro-iliac disease.

Abscess finally forms in the majority of cases. It may be extra- or intra-pelvic. The intra-pelvic abscess may present above the crest of the ilium, or the pus may pass through the sciatic notch, or appear in the ischio-rectal fossa, or break into the rectum.

Diagnosis.—Sacro-iliac disease may be mistaken for SCIATICA, or for disease of the HIP OR SPINE. The freedom of motion and the absence of muscular spasm when the pelvis is fixed, if the examination is carefully conducted, should exclude both the one and the other, although the pain on lateral pressure which is described as the most characteristic symptom, may be simulated closely by primary acetabular disease. The attitude is similar to that of sciatica, but the symptoms of local sensitiveness to jars and to manipulation are much more marked.

Prognosis.—According to the statistics the prognosis is very unfavorable, probably because the majority of the reported cases were in adults and were complicated by infected and burrowing abscesses, which constitute the chief danger of this form of tuberculous disease.

Treatment.—The local treatment consists in protecting the diseased parts from injury, and in the radical removal of the disease if it has reached the stage of abscess formation.

In the ambulatory treatment, a plaster spica bandage, or a double Thomas hip brace combined with the use of crutches may be indicated, but in most instances a broad, strong pelvic girdle which may be drawn tightly about the pelvis, will be most efficient. If motion of the spine causes discomfort, this girdle may be reinforced by some from of spinal brace. If the disease is progressive rest in bed will be necessary.

When abscess is present radical treatment is, as a rule, indicated. The articulation should be freely exposed and the diseased bone should be entirely removed, if possible. Intra-pelvic abscess should be drained through a direct communication, in order to check, if possible, the tendency toward burrowing.

Injury of the Sacro-iliac Articulation.—In some instances the symptoms of sacro-iliac disease are apparently due directly to falls on the buttock or pelvis. In such cases the symptoms are readily relieved by support, and the presence of actual disease seems to be doubtful.

CHAPTER III.

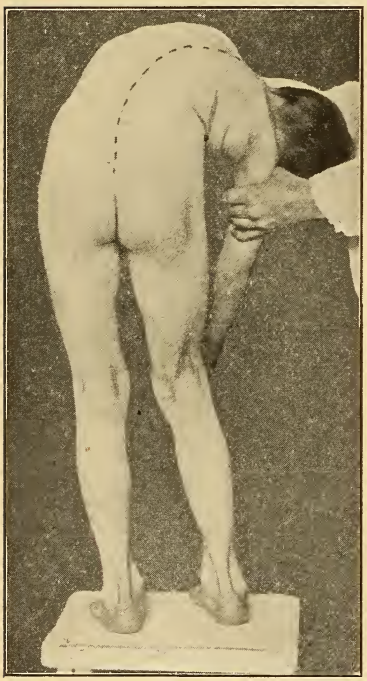
LATERAL CURVATURE OF THE SPINE.

Synonyms.—Rotary Lateral Curvature—Scoliosis.

Lateral curvature of the spine is an habitual or fixed deformity in which the spine is deviated in whole or part to one or the other side of the median line.

By limiting the term to habitual deformity one excludes simple postural inclination of the spine. For example, if one leg were considerably shorter than the other the pelvis would be tilted downward on the short side and there would be a compensatory curvature of the spine in the erect attitude, which would disappear in the sitting posture. This accommodative curvature, and those of similar origin, would not be designated as lateral curvature of the spine.

FIG. 68.



Physiological rotation accompanying flexion and lateral inclination of the trunk in the normal subject.

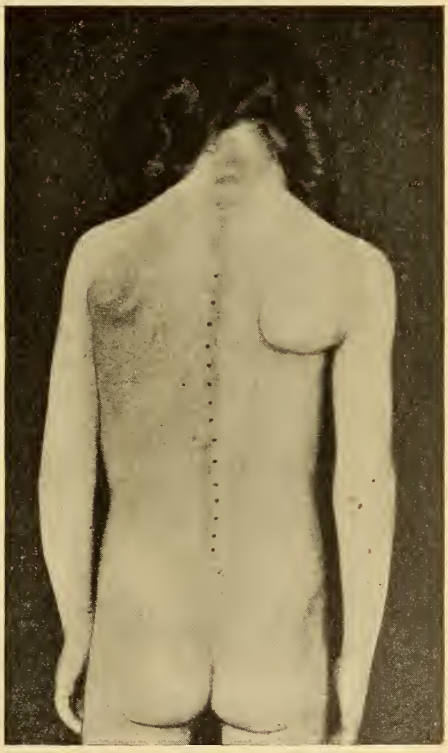
In persistent lateral curvature the anterior part of the column, made up of the bodies of the vertebræ that support the weight, is more distorted than are the spinous processes, because lateral distortion is always accompanied by a certain degree of twisting or rotation of the vertebral bodies. This rotation is in the direction of the convexity of the curve, and as the bodies rotate the spinous processes are carried in the reverse direction. Thus it is that well-marked rotation may be present, although there may be comparatively little lateral deviation of the line of the spinous processes.

In the physiological movements of the spine, simple, direct lateral motion, that is, motion allowed by the small joints of the spine and by the lateral compression of the intervertebral discs, is very limited; the larger movements must be accompanied by rotation of the vertebral bodies by which this continuous or solid part of the column is, as it were, forced from the shortened to-

ward the lengthened side. (Fig. 68.) When for example, one flexes the head to bring the ear as near the shoulder as is possible there is necessarily an accompanying rotation of the chin in the opposite direction caused by the twisting of the bodies of the cervical vertebræ toward the convexity of the curve. Thus torticollis, in which the neck is held in this attitude, causes often a fixed rotary lateral curvature of the cervical vertebræ.

In the simple accommodative lateral inclination of the body to one side or the other, the change in contour of the spine would be more noticeable if it could be observed from the front rather than from the back, and as lateral curvature is simply a persistent deviation of the spine, one of the so-called static deformities which are directly induced or exaggerated by superincumbent weight, it is probable that rotation of the vertebral bodies precedes, in most instances, the lateral distortion that first attracts attention.

Fig. 69.



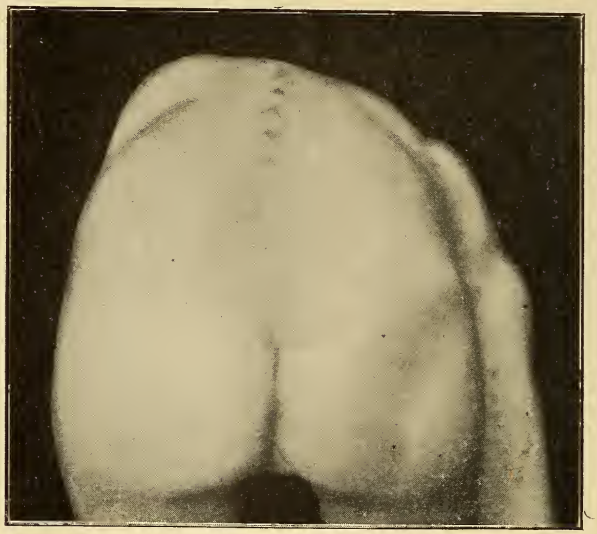
Congenital total scoliosis. Compare with Fig. 70.

It is probable also that slight rotation may not cause at once an appreciable degree of external distortion, and although marked lateral curvature is necessarily combined with rotation, yet it is possible that a slight degree of direct lateral deviation may exist unaccompanied by appreciable rotation. Rotation is usually understood to imply fixed deformity, while lateral deviation may mean simply an habitual posture; but it is far simpler to consider the two as parts of one distortion. The true and important distinction is between *habitual deformity*, implying the habitual assumption of an improper attitude in which the accommodative changes in structure have not advanced sufficiently to prevent voluntary or passive correction, and *fixed deformity* in which the changes in the bones and other tissues have made cure difficult or impossible. The evidence of fixed deformity is rotation that persists after the lateral deviation has been overcome. It persists because the early and important changes must take place in the bodies of the vertebræ that support the weight,

but there is no reason to believe that habitual rotation as an accompaniment of habitual lateral curvature may not be corrected if it be treated at the proper time.

The necessity for dividing the weight about the center of gravity in order to balance the body in the upright position accounts for the distribution and effects of lateral curvature. As the normal contour of the spine is the necessary result of static conditions, a change from this normal relation of one part necessitates a corresponding change elsewhere. If there be a primary lumbar curvature and rotation to the left in the lower region, a corresponding lateral deviation and rotation to the right in the region above usually develops, thus restoring the balance of the body. This explains the ordinary S-shaped or double curve of scoliosis, one of which is primary and the other sec-

FIG. 70.



Congenital total scoliosis. The rotation is much greater than the lateral deviation. Compare with Fig. 69.

ondary. These curves may divide the spine equally or there may be a long and a short one, and occasionally three distinct curves may be present. If the primary curve is slight, the secondary curvature will be slight also, and the primary curve persists doubtless for a time before the secondary distortion appears. In some instances the spine may be bent laterally into one long curve, "total scoliosis." (Fig. 68.) This is probably, in many instances at least, the initial stage of the ordinary type of scoliosis, the long curve being afterwards divided, although it may persist. In childhood, total scoliosis is often combined with general posterior curvature and it is peculiar in that the torsion of the vertebræ may be toward the concave instead of the convex side, as is usual, the torsion representing probably the early stages of the secondary or compensatory curve.

It has been stated that deformity of one part of the spine is usually balanced by deformity of another. This enables the trunk to hold the erect posture and it restores its general symmetry. If, however, a long lateral or a long posterior curvature persists, the weight can be balanced only by swaying the entire body on the pelvis, in the

FIG. 71.

Primary lumbar curvature to the left. A "flat back" marked rotation with but slight lateral curvature.

direction opposed to the distortion. This restores the balance, but not the symmetry. (Fig. 63.)

ROTATION AND LATERAL DEVIATION.—Fixed rotation of the spine carries with it of course all the parts that are attached to it. When the patient stands in the erect attitude the simple lateral distortion is most noticeable, but when the body is bent forward the twist of the trunk becomes the prominent deformity. (Fig. 69.) If the thoracic region is involved, the ribs, on the side toward which the spine is

rotated, project backward and on the other side of the spine there is an abnormal flatness or depression. The projection of the ribs due to the twisting of the thorax is far more noticeable than is the simple twisting of the free portions of the spine in the neck or loins; and in these regions the projecting transverse processes covered by the thick layers of muscles yet unaccompanied by marked lateral deviation, may cause mistakes in diagnosis. In the cervical region, as an accompaniment of acute torticollis, the projection may be mistaken for abscess; and in the lumbar region it has been mistaken for a new growth attached to the spine.

FIG. 72.

Scoliosis with marked posterior deformity.

Although persistent lateral curvature of the spine is always accompanied by rotation, the degree of rotation does not always correspond to that of the more evident lateral deviation. In the instances cited, extreme rotation in the lumbar region may exist with but slight lateral distortion; while in other cases the body appears to be greatly displaced to one side, although there may be comparatively little fixed rotation. Again, as has been stated, the lateral deviation of the trunk is usually more noticeable than the rotation, which in the slightest grades of deformity is only made apparent when the patient is bent forward so that the back may be inspected in the horizontal position. It may be noted also that the degree of habitual lateral distortion of the body does not correspond to the degree of fixed distortion. One individual, by voluntary effort, may practically conceal advanced deformity, while another who makes no effort to correct the improper posture, appears to be greatly distorted although the fixed changes may be very slight.

The effects of the deformity, both general and local, depend upon its situation and its degree. In one instance it may be so slight as to pass unnoticed, and in another the distortion may equal that of Pott's disease. (Fig. 80.) If compensation be perfect, that is, if the deformity is equally distributed on either side of the median line, the general sym-

metry of the body may be but slightly disturbed. Or if the compensation for the primary deformity of the lumbar region is distributed throughout the remainder of the spine, noticeable distortion may be insignificant, but when there is a long curve involving the thoracic region, the lateral and posterior displacement cannot be concealed. (Fig. 73.)

Changes in the Antero-Posterior Contour.—Lateral distortion involves also secondary changes in the antero-posterior outline of the spine. When the distortion is marked the stature is shortened, sometimes very noticeably. This shortening is, of course, greater when the antero-posterior curves are increased in addition to the lateral deviation. And, in general, one may recognize two types of lateral curvature, one in which the back is flatter than normal, in which the antero-posterior curves are diminished, and another in which they are increased.

It has been stated in the account of Pott's disease that deformity in one segment of the spine always caused a change in the contour of the spine as a whole, that an obliteration or a lessening of the concavity of the lumbar region was accompanied by a corresponding flattening of the normal dorsal kyphosis. On the other hand, an increase in the backward projection of the dorsal region caused an increase in the concavity of the parts below. It is probable that the same explanation may account for the secondary changes in the antero-posterior contour of the spine in lateral curvature. In the one instance the primary deformity is of the lower region, and with its accompanying backward twist of the vertebral bodies it lessens the lumbar lordosis and tends to flatten the back. (Fig. 71.) If, on the other hand, the deformity begins in the thoracic region, the primary effect is to increase the backward projection, and this in turn tends to exaggerate the lumbar lordosis. (Fig. 72.) Thus the shortening of the trunk caused by the lateral deviation may be to a certain extent compensated in the first instance, while in the other both the primary and secondary distortions tend to reduce the height.

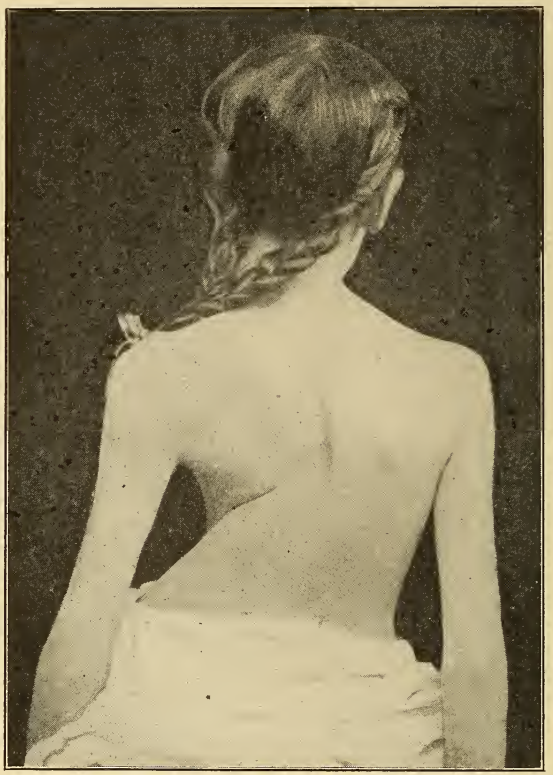
The "High" Shoulder and the "High" Hip.—When the convexity of the primary curve is, for example, to the left in the lumbar region, the trunk is displaced somewhat to the left, consequently the right "hip" becomes abnormally prominent; and in compensation for the displacement below, there is a corresponding twist in the opposite direction above. The spine bending, and at the same time rotating toward the right, carrying with it the ribs, elevates the shoulder and makes the scapula prominent. Thus it is that in the ordinary S-shaped curve the high shoulder and the projecting hip appear usually upon the same side of the body. But in less regular varieties of distortion, when, for example, there is marked general lateral deviation, the high shoulder may be on the opposite side. (Fig. 79.) The final effect, as far as the lateral deviation is concerned, is much the same whether the curvature is primarily of the dorsal or of the lumbar region, and there is much uncertainty as to the relative frequency of the

primary distortion because few cases are seen in the early stage or before compensatory changes have appeared.

Pathology.—Lateral curvature of the spine is a deformity, not a disease, nor is it in the ordinary cases a result of disease. For this reason the description of the pathology which is merely a more detailed account of the deformity and of its secondary effects upon the trunk and its contents may, for convenience, precede the discussion of the etiology.

In such a description one must consider the spine as a whole, a column bent and twisted, in which each component segment bears its

FIG. 73.



Scoliosis with extreme lateral deviation.

share of the general distortion. The vertebra at the apex of each curve shows the greatest change. If the rotation and lateral deviation is to the right the vertebral body is somewhat wedge-shaped, the apex of the wedge being directed backward and to the left. Its lateral diameter is increased and the superior and inferior margins at the narrow side overhang the center of the body, increasing the lateral concavity. (Fig. 77.) Similar accommodative changes, although less marked, are to be found in the articular processes and in the laminæ; in fact all the parts on the concave side are broadened, shortened and lessened in

vertical diameter as compared with those on the convex side of the spine. These changes affect the shape of the neural canal, which becomes somewhat ovoid in outline, the base being directed toward the

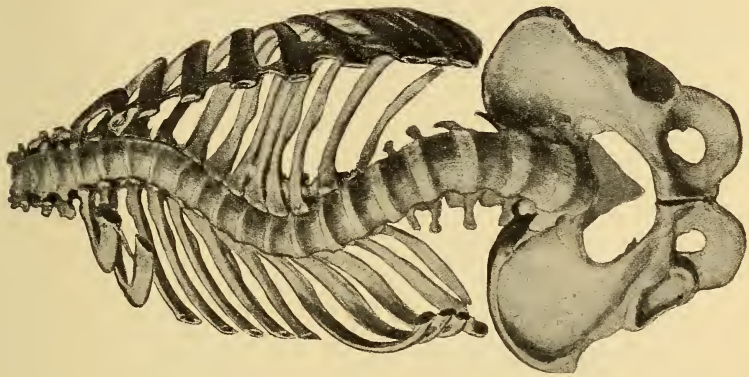


Fig. 76.

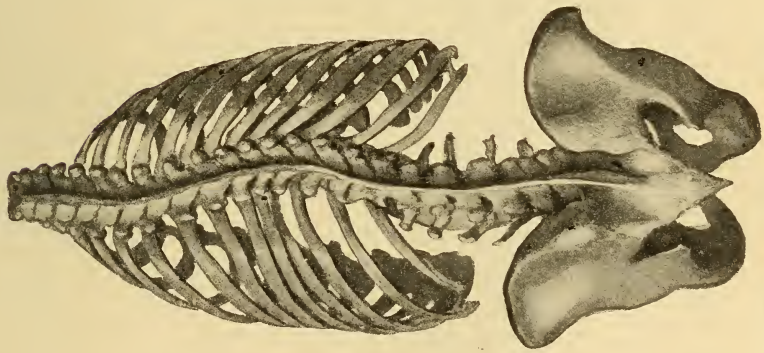


Fig. 75.

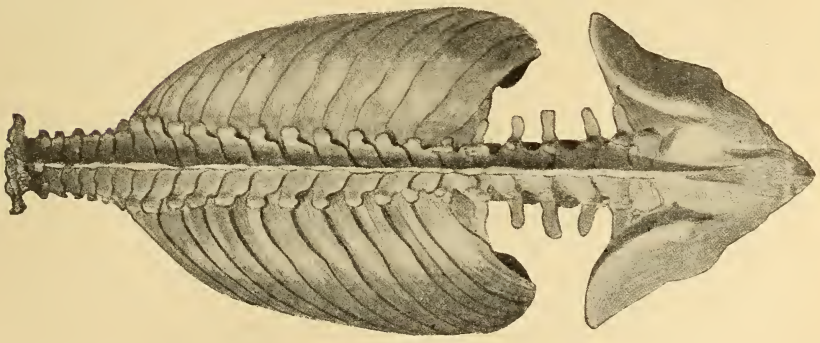


Fig. 74.

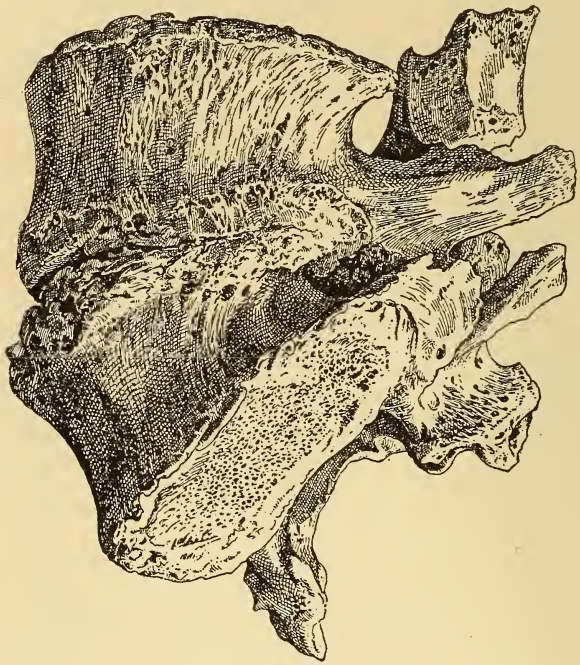
The normal spine, contrasted with the scoliotic spine. (Pfeiffer.)

convexity of the curve. (Fig. 78.) In the vertebræ included in the compensatory curvature, the deformities are reversed, and the intermediate segments show the transitional changes between the two ex-

tremes. The intervertebral discs become wedge-shaped also, and atrophied on the side subjected to greatest pressure, the changes in these softer tissues preceding, undoubtedly, those in the bones. The articulations of the vertebræ become changed in shape and position in the general adaptation to the deformity and the ligaments are shortened or lengthened according to their relation to the distortion.

On section, the internal structure of the vertebræ shows the same adaptive changes that are evident on the exterior. In the narrowed parts of the bones that bear the weight, the tissue is thick and compact, and on the opposite side it is atrophied from disuse.

Fig. 77.



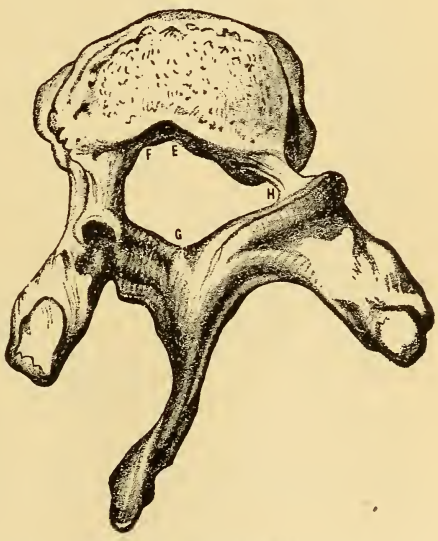
Scoliotic vertebræ. (Hoffa.)

The mobility of the spine is lessened by these changes in its shape and structure; primarily by the distortion, and by the shortening of the tissues on the concave side, finally by the interference of the newly formed, or transformed bone which is thrown out about the margins of the vertebræ and the articular processes, and by the distortions of the vertebral bodies. Thus in fixed deformity there may be, at the points of greatest distortion, practical anchylosis. The muscles of the back, both intrinsic and extrinsic, undergo adaptative changes, and, as a rule, they are, in general, relatively weak, and especially so if the motions of the spine are much interfered with.

The distortion of the vertebral column causes, of course, a distortion

of the trunk of which it is the support, and this distortion is of the greatest importance in its effect upon the thorax. The deformity of the thorax is somewhat difficult to describe because the distortion of the dorsal vertebræ does not affect the thorax equally, thus it is not twisted as a whole, nor flexed as a whole. The nature of the distortion may be better understood by considering the sternum as a fixed point; this, as a matter of fact, it is, as compared with the spine. At the apex of the convexity of the curve the ribs are drawn sharply backward with the transverse processes to which they are attached; their angles project by the side of, and beyond, sometimes covering and concealing the spinous processes, and the lateral convexity of the chest is diminished or lost. On the opposite side the back is broadened and flattened. The effect of the rotation is to diminish the capacity of the chest, on the convex side and to increase that of the concave side. (Fig. 79.) On the convex side the ribs are elevated, and their inclination is increased. On the concave side the intercostal spaces are narrowed and the inclination is lessened. (Fig. 75.) The antero-posterior diameter of the chest is increased or diminished according to the change in the antero-posterior contour of the spine. If the dorsal kyphosis is exaggerated, the effect is to deepen the chest (Fig. 72); if it is diminished, the diameter of the thorax is correspondingly lessened.

Fig. 78.



Change in shape of the spinal canal, broader on the convex side. (Hoffa.)

The cervical section of the spine is not often involved, to a marked degree, at least in the lateral deformity. But in extreme cases, in which the neck and head are habitually distorted, the skull may show secondary changes similar to those induced by persistent torticollis.

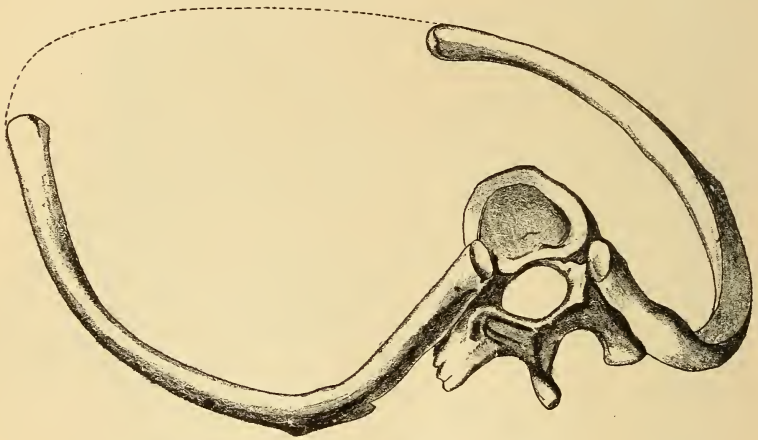
At the other extremity of the spine, the pelvis is not, as a rule, noticeably deformed. In some instances the oblique diameter, opposed to the convexity of the lumbar deformity, may be increased, and if the lateral deviation of the lumbar spine is extreme, the pelvis may be so tilted that the limb on the elevated side becomes practically shorter than its fellow.

In the changes that have been described, the contents of the trunk participate to a greater or less degree. The lung on the convex side is more or less compressed by the distorted ribs and by the displaced vertebral bodies. The heart may be displaced laterally or upward, ac-

cording to the position of the deformity, and the blood vessels are changed in direction, and, it may be, altered in calibre. In those cases in which the thorax is markedly distorted, the effect is similar to that of the deformity of Pott's disease; respiration is shallow and rapid, the pulse rate is usually increased and other evidences of interference with the vital functions may be apparent. The abdominal organs are affected doubtless, in a similar manner, but symptoms due to this cause are not, as a rule, as clearly marked.[1]

Etiology—Relative Frequency.—Lateral curvature of the spine is one of the most common of deformities. In the past fifteen years, 1885–1899, 3,252 cases were recorded in the Out-patient Department

FIG. 79.



Deformity of the thorax in scoliosis. (HOFFA.)

of the Hospital for Ruptured and Crippled, a number only exceeded by that of bow legs, of which 5,030 cases were treated during the same period.

The only statistics bearing upon the relative frequency of lateral curvature among children in general are those of Drachmann who found among 28,125 school children (16,789 boys, 11,386 girls) of Denmark 368 cases of scoliosis (1.3 per cent.).

Sex.—Lateral curvature of the spine is far more common among females than males. Of the 3,252 cases referred to 2,554 (78.5 per cent.) were in females and 698 (21.4 per cent.) were in males.

The lowest percentage of males in any one of the fifteen years was 14.8, the highest 25.1. This proportion of one male to four females is somewhat larger than in the smaller groups of cases reported by other observers.

The unequal distribution of the deformity between the sexes is of great interest as bearing on the question of etiology; especially so as

[1] Bachman, Die Veränderungen an den inneren Organen bei hochgradigen Skoliosen und Kyphoskoliosen. Bibliotheca Medica Ab. D. 1, H. 4, 1900.

in the cases that develop in early childhood, sex appears to exercise practically no influence. It has been suggested that curvature of the spine in a girl is looked upon with more solicitude by the mother than is the same deformity in a boy, therefore more girls are brought for treatment. There may be some basis for this argument, for it is certain that distortion of the lower extremities are considered of greater importance in male than in female children because of the concealment to be afforded by the skirts, if the deformity is not outgrown. But granting that statistics are somewhat unreliable, there can be no doubt but that this deformity is far more common among girls than boys and that the disproportion may be explained, in great part at least, by the differences in dress and in manner of life.

Age.—1,299 (39.9 per cent.) of the 3,252 patients referred to were less than fourteen years of age. 1,576 (48.4 per cent.) were between fourteen and twenty-one. 377 (11.6 per cent.) were more than twenty-one years of age. These statistics simply show the age of the patients at the time treatment was sought, and they are of little value as an indication of the age at which deformity might have been detected had it been looked for.

There is no reason to suppose that lateral curvature of the spine differs in its etiology from similar deformities of other parts, except in so far as each region of the body is more or less susceptible to deforming influences at one time than another.

For example, rhachitic deformities of the upper extremities are practically never seen except in infancy, and they begin to correct themselves when the erect posture is assumed or at the very time when distortions of similar origin of the lower extremities develop. But when deformities of this class appear in later childhood or adolescence it may be assumed that, in many instances at least, the tendency toward the particular deformity, or even a slight degree of deformity, was acquired at an early age, that it remained latent until the conditions appeared which favored its further development. This point is illustrated by the statistics of Eulenburg of 1,000 cases of lateral curvature analyzed with reference to the inception of the deformity.

Between birth and the sixth year	78
Between the sixth and seventh years	216
Between the seventh and tenth years	564
Between the tenth and fourteenth years	107
After the fourteenth year	35
	1,000

It will be noted that but 142 (14.2 per cent.) of the patients were more than fourteen years of age as contrasted with the general statistics of the Hospital for Ruptured and Crippled, in which 60 per cent. were beyond this age.

Dr. Walter Truslow, who for several years has had the immediate charge of the treatment of lateral curvature at the Hospital for Ruptured and Crippled, has prepared for me statistics of a number of the cases

under treatment by gymnastic exercises, which illustrate the same point.

A.

AGE WHEN TREATMENT WAS BEGUN.

Age when examined.	Males.	Females.	Total.
4 years	0	1	1
5 "	0	1	1
6 "	1	1	2
7 "	4	2	6
8 "	4	7	11
9 "	4	4	8
10 "	2	7	9
11 "	3	13	16
12 "	3	16	19
13 "	4	28	32
14 "	5	25	30
15 "	3	21	24
16 "	8	14	22
17 "	2	6	8
18 "	1	2	3
19 "	0	1	1
20 "	0	1	1
21 "	0	4	4
23 "	0	1	1
24 "	0	1	1
32 "	0	1	1
	44	157	201

B.

AGE WHEN THE DEFORMITY WAS DISCOVERED.

		Males.	Females.
Congenital	2	sex not stated.	
During infancy	19		
Between 3 and 6 years	16	10	6
" 6 " 10 "	41	10	31
" 10 " 13 "	62	6	56
" 13 " 15 "	27	3	24
Over 15 "	14	3	11
Unknown	20		
	201	32	128

But 44 of the 181 patients (22.6 per cent.) were more than 13 years of age at the time when the deformity was first noticed, although nearly 50 per cent. were older when treatment was applied for. In the first table it will be noted that of the 38 patients who were 10 years of age or less, 15 or about 40 per cent. of the number were males. In 25 of the 37 patients in whom the deformity is supposed to have developed at or before the sixth year, rhachitis was the apparent cause.

Lateral curvature of the spine is one of the penalties of the erect posture, and the force of gravity must be considered both as a predisposing and as an exciting cause of the deformity.

The more direct tendency of the force of gravity is to cause the body to fall forward and to increase the posterior curvature of the spine, but whenever there is a persistent inclination of the spine to one or the other side, this inclination is likely to be increased to deformity under favoring conditions. These favoring conditions would include general weakness from any cause; overwork that may induce fatigue, and all factors, mechanical or otherwise, that may add to the difficulty of holding the trunk erect under the pressure of the superincumbent weight.

Although it is not difficult to suggest the predisposing causes of lateral curvature, it is by no means as easy to point out the direct cause of the original inclination of the spine to one or the other side of the median line that is the first step toward fixed deformity. In a certain number of cases, however, the relation between cause and effect is sufficiently evident and these causes may be enumerated before considering the larger class in which the etiology is more obscure.

1. Lateral curvature, secondary to deformity of other parts.
2. Static or mechanical deformity.
3. Deformity secondary to disease of the nervous system.
4. Deformity secondary to disease of the thoracic organs.
5. Incidental deformity.
6. Deformity due to occupation.
7. Congenital deformity.
8. Rhachitic deformity.

1. Lateral Curvature Secondary to Deformity Elsewhere.—(*a*) Lateral curvature of the spine may be a compensatory effect of torticollis, either congenital or acquired. (*b*) It may be induced by distortion or inequality of the lower extremities. For example, fixed adduction of the thigh necessitates an upward tilting of the pelvis whenever the limb is brought into the normal line, whether the patient is standing, sitting or lying; and this deformity when extreme, may induce lateral curvature even in bed-ridden patients. The same effect is sometimes observed in certain instances of inequality of the length of the lower extremities. In the erect posture the pelvis is tilted downward on one side, and this in turn necessitates a twist of the spine.

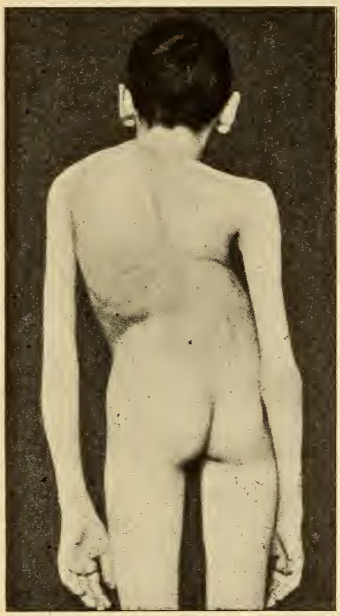
2. Static Deformity.—Simple inequality of the limbs does not appear to be a common cause of fixed deformity because its influence ceases in the sitting and reclining postures, and because the inequality is so often compensated, if it be extreme, by walking on the toe or by raising the sole of the shoe.

An increase in the length of a limb, such as may be caused by a fixed equinus of the foot, seems to have more influence in causing secondary deformity than does shortening, possibly because no attempt is made to compensate for the inequality.

3. Lateral Curvature Secondary to Paralysis.—Lateral deformity of the spine may be caused indirectly by a number of distinct diseases of the nervous system, but in this connection only one

need be considered—anterior poliomyelitis. This form of paralysis may act in several ways. It may induce deformity by distortion of a lower extremity or by inequality in the length of the limbs due to retardation of growth. It may predispose to deformity by the general weakness that it causes, or the trunk may be unbalanced by loss of function in one of the upper extremities, but the more extreme cases of deformity are caused by unilateral paralysis of the muscles of the trunk. As a result, the expansion of one side of the thorax is interfered with and the unaffected, or less affected, side taking on increased activity, develops at the expense of the disabled part.

FIG. 80.



Scoliosis following empyema at the age of 2 years. Present age 19 years.

FIG. 81.

Scoliosis secondary to lumbar Pott's disease in early childhood.

Thus the convexity of the curve is usually toward the sound side.

4. LATERAL CURVATURE SECONDARY TO DISEASE WITHIN THE THORACIC WALLS.—The most common cause of deformity of this class is persistent empyema. The lung is primarily compressed by the effused fluid, and its function is finally impaired or abolished by the adhesions that form between it and the chest wall, as well as by the extension of the disease to its structure. As a result, the side of the chest is retracted while the function of the unaffected lung is increased.

(Fig. 80.) Thus, as in paralysis, the spine curves with the convexity toward the active side.

Other affections of the lungs that interfere with the function of one side may induce lateral curvature, but the influence is less marked and direct than in empyema.

5. Incidental Lateral Curvature.—Lateral curvature may be caused by direct injury or by disease of the spine, for example by fracture or by Pott's disease. (Fig. 81.) Distortion as a symptom of sacro-iliac disease, or the more marked deformity caused by sciatic or lumbar neuritis (Fig. 67), may if persistent finally induce slight permanent deformity, but such cases hardly deserve special consideration.

6. Lateral Curvature due to Occupation.—Lateral curvature of milder degree is incidental to certain occupations that require habitual inclination of the body. It is said to be very common among stone cutters, for example. Such deformity developing after the growth of the body has been attained, is, of course, of interest as throwing light upon the etiology of the ordinary form of lateral curvature. For if habitual occupation can thus change the contour of the developed spine, it is evident that similar postures, though far less constant, may influence the spine of a growing child, particularly in one predisposed to such distortion.

7. Congenital Lateral Curvature.—Congenital scoliosis is uncommon (Fig. 82) in infants otherwise normal, and but few cases have come under my observation at an age sufficiently early to make the diagnosis absolutely certain. One case, in an otherwise well-formed male infant, was seen at the age of three months. There were well-marked lateral deviation and rotation in the dorsal region that had attracted attention soon after birth. A second case, in a female child, was seen at about the same age. The deformity was extreme, and contracted tissues on the concave side prevented the straightening of the spine. There was also an accompanying lumbar hernia.

The first patient was cured by manipulation and posture before the completion of the first year; the second, now six years of age, is still under treatment. A number of cases have been collected from literature by Hirschberger.[1]

8. Rhachitic Lateral Curvature.—Rhachitis predisposes to deformity of all parts of the body by weakening the resistance of all the tissues. As is well known, the common deformities from this cause are the so-called rhachitic kyphosis that develops in the sitting child, and the distortions of the lower extremities in those who stand and walk. Lateral curvature of the spine sometimes accompanies the kyphosis in those who do not walk, or it may exist independently of it. The lateral inclination is induced doubtless by the manner of sitting or by the manner in which the child is supported on the mother's arm; for at this period of rapid growth and increased susceptibility to deforming influences, even slight and temporary causes of this na-

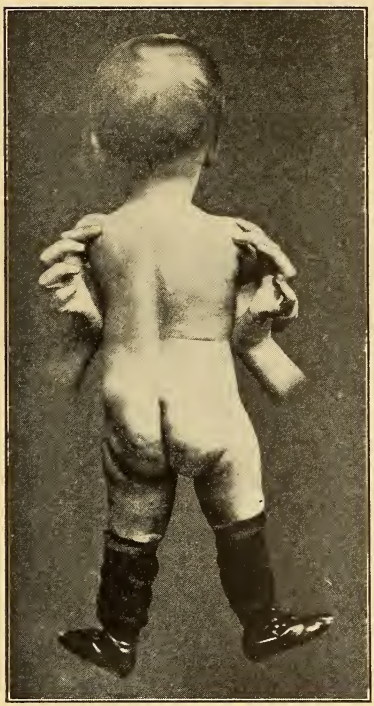
[1] Beiträg zur Lehr der Angeboren Skoliosen, Zeits. f. Ortho. Chir., B. 7, H. 1, 1899.

ture may be sufficient to induce the distortion. (Fig. 83.) Again, when the child begins to walk, the tilting of the pelvis due to distortion of the limbs, for example to unilateral knock knee, may also serve to disturb the equilibrium of the body and thus to induce lateral distortion.

How common rhachitic lateral curvature may be it is impossible to say, but it is probable that if all rhachitic infants and children were carefully examined, this deformity would be discovered in many instances in which its existence had not been suspected.

In about 15 per cent. of the cases tabulated by Truslow the influence of one or more of the causes that have been enumerated seemed to be apparent, viz.:

FIG. 82.



Congenital scoliosis.

FIG. 83.

Rhachitic scoliosis.

Congenital deformity	2
Torticollis	2
Empyema	4
Anterior poliomyelitis	3
Inequality of the legs of more than ½ inch	6
Rhachitis	13
Total	30

In the remaining cases, 85 per cent., the direct cause of the deformity was somewhat conjectural.

Hereditary Influence.—By many writers the influence of heredity is considered an important factor in the etiology. That there is such an influence, predisposing to disease as well as to deformity, is undoubted, but it is very difficult to establish its connection with the ordinary cases. In 11 of 201 cases, lateral curvature was present in either the father or mother of the patient. And in 17 others a brother or sister of the patient was deformed in a similar manner.

Occupation.—It is well known that occupation may induce deformity in the adult and one looks naturally to occupation as a factor in the causation of lateral curvature in childhood. Occupation in this class implies school, and it may be assumed that the sitting posture during school hours may cause fatigue especially if the chair is unsuitable or uncomfortable. (Figs. 84, 85.) Under the influence of fatigue an improper attitude is likely to be assumed which may become habitual, its character being influenced by the arrangement of the light or by the shape of the desk. When a habit of posture is acquired it is likely to persist when the sitting posture is assumed elsewhere than at school and the greater liability of girls to the deformity may be explained in part by the fact that they sew, or read, or play on the piano, while boys are usually engaged during the same period in active exercise.

In Truslow's tables the occupation is noted in 400 cases of lateral curvature; also other habits that may have influenced the deformity.

Occupation.	
School	285
Factory	19
Clerk	13
Domestic	8
Millinery, Dressmaking, etc.	8
Messenger	3
Housewife	3
Teacher	2
No occupation	59
Total	400

Posture.		
Weight on right foot	48	96
" " left "	48	
Carries books or baby on right arm	38	74
" " " " " left "	36	
Sits at desk or work in faulty attitude	57	
Carries heavy load on one shoulder	2	
Excessive use of right arm in occupation	3	
Total	232	

The sitting posture is not the only one in which improper attitudes may be persistently assumed, in fact it has been suggested that the posture during sleep may influence the inclination of the body during

FIG. 84.

Posture induced by improper desk and chair. (SCUDDER.)

FIG. 85.

Posture induced by improper chair. (SCUDDER.)

the hours of activity. But the sitting posture is the one in which the muscular support is most likely to be relaxed, and in which a tendency toward lateral inclination is most likely to be acquired, since children do not often retain a fixed attitude in the erect posture for any length of time. For this reason, inequality in the length of the limbs is of less importance as a cause of distortion than it would otherwise be. Bradford and Lovett record an observation of the attitudes of 67 healthy adults undergoing a written examination. At the end of the second hour a lateral inclination of the body was evident in all, and in three-fourths of the number the general inclination of the body was to the right. In at least this proportion of the cases of lateral curvature the type of fixed deformity is to the left in the lumbar and to the right in the dorsal region, and it is natural to look upon the occupation as the important factor in determining the direction of the deformity. If it be assumed that the distortion is caused or influenced by the attitude assumed during school hours it would appear that the primary deformity should be more often of the lumbar region, for in the sitting posture the lumbar lordosis is lessened or lost, thus the bodies of the vertebræ in the lumbar region would be subjected to greater pressure than in the dorsal region, a pressure which might induce the changes in the bones that accompany deformity.

The possibility of distinguishing the varieties of lateral curvature in which the primary distortion is lumbar from those in which it is dorsal, by the flattening of the dorsal kyphosis in the former, and its exaggeration in the latter instance, has been mentioned.

Varieties of Deformity.—According to the statistics from various sources about three-fourths of the well-developed double curves of the spine are convex to the right in the dorsal and to the left in the lumbar region, and as the distortion of the thorax is the more noticeable of the two it usually classifies the deformity as right or left. The dorsal curvature may be either primary or secondary, and the relative frequency of the original deformity, whether lumbar or dorsal, is in doubt with the probabilities in favor of the former.

Summary of Varieties of Deformity of the Spine under treatment 1899–1900, at the Hospital for Ruptured and Crippled, tabulated by Dr. Truslow.

1. Simple Antero-posterior Deformities.

(*a*)	Kyphosis	10
	Kypho-lordosis	1
	Lordosis	1
		12

Round Shoulders.

(*b*)	Abducted scapulæ	7	
	Elevated scapulæ	2	
		9	Total, 21

2. Antero-posterior Abnormalities most Marked, but Accompanied by Lateral Deviation.

(*a*) With single lateral curve.....14
(*b*) With double lateral curve.....16
(*c*) With triple lateral curve..... 7
37

3. Rotation most Marked, but Accompanied by Lateral Deviation.

(*a*) With double lateral curves.....22
(*b*) With triple lateral curves..... 8
30

4. Lateral Deviation most Marked, Direction of the Curves.

Right Dorsal, Left Lumbar Type.

(*a*) Single lateral curve.....22
(*b*) Double lateral curve.....71
(*c*) Triple lateral curve..... 6
99

Left Dorsal, Right Lumbar Type.

(*a*) Single lateral curve..... 3
(*b*) Double lateral curve..... 8
(*c*) Triple lateral curve..... 3
14 Total, 201

It will be noted that in 21 instances antero-posterior deformity existed without lateral deviation, and that in 37 instances it was accompanied by lateral deviation. In the remaining 144 cases, rotation was more marked than lateral deviation in 30 cases, and lateral deviation more marked than rotation in 113. In the entire number of cases in which lateral deviation was present it was single in 39 cases, double in 117 cases, triple in 24 cases.

In 373 cases of lateral curvature tabulated by Lüning and Schulthess the deformity was as follows:[1]

	Left.	Right.	Total.
Total scoliosis (single curve affecting the entire spine).....	79	16	95
Lumbar scoliosis (single curve limited to the lumbar region).....	14	3	17
Lumbo-dorsal scoliosis (single curve limited to lumbo-dorsal region)...	49	60	109
Complicated scoliosis.			
(*a*) Right dorsal, left lumbar.....		123	
(*b*) Left dorsal, right lumbar.....	29		152
	171	202	373

It will be noted that a very large proportion of these cases were in the early stage of deformity as indicated by the absence of compensatory curves; that in 82 per cent. of the 112 cases in which the curve was general or most marked in the lumbar region, the inclination was to the left, and of the complicated or more fully developed

[1] Zeits. für Orth. Chir., Bd. V.

cases in which the curve was double, 80 per cent. were of the right dorsal left lumbar type.

Symptoms.—In the large proportion of cases the first symptom of the affection is the deformity. This is often discovered by the dressmaker at the age when the clothing is made to fit the figure more closely. In certain instances the deformity may be preceded or accompanied by pain. This was present to a greater or less degree in about one-quarter of the cases examined by Truslow. Pain may be simply the discomfort or the dragging sensation of fatigue, usually referred to the lumbar region, or it may be severe and neuralgic in type. The latter variety is more common in the cases in which the deformity is extreme. It is said to be the result of pressure on nerves, but this is doubtful as it is often referred to the convex as well as to the concave side. There are also more general symptoms of a neurasthenic or hysterical nature that may be due in part to the deformity and in part to the debility of which it may be a result or accompaniment. For it must be borne in mind that lateral curvature is, in many instances, symptomatic of debility, as is shown by the fact that it is often accompanied by other deformities, particularly by the weak foot. In many instances symptoms of weakness and awkwardness precede the deformity. Truslow states that in a large proportion of the cases investigated the patients had been distinctly less active than their companions, that they did not enjoy exercise and were inclined to lead sedentary lives. Teschner[1] has called attention to the same peculiarity. He states that the patients are often indifferent, apathetic and lazy. He has noted also a peculiar lack of coördination and muscular control as a common symptom. These symptoms apply particularly to the period of adolescence, the time of rapid growth and instability, when any latent deformity or weakness is likely to be exaggerated. In younger subjects such symptoms are far less marked, or are absent. In the cases in which the deformity is extreme, symptoms due to interference with the respiratory and circulatory apparatus, or caused by the displacement of the abdominal organs, may be present. These are, however, rather unusual.

Diagnosis. POSTURE.—Lateral curvature of the spine is a simple deformity unaccompanied by the symptoms of disease. When the patient stands with the back and hips bare, the inclination of the body to one or the other side and the general want of symmetry, are usually apparent, even in the earliest stage of the affection. For, as has been stated, the habitual assumption of a certain posture precedes fixed changes in and about the spine, and this posture will appear when the patient is asked to stand in the usual manner. If the inclination of the body is toward the left (Fig. 69), the left arm will hang in close apposition to its lateral border, while on the right side an interval will appear between the arm and the trunk. If there be a slight lumbar curve to the left (Fig. 71), the right iliac crest will be accentuated.

[1] Medical Record, Dec. 16, 1893.

The curvature in the dorsal region makes one shoulder higher than the other (Fig. 83), the scapula on the affected side projects and the distance between its posterior border and the median line is increased. Rotation of the spine is shown by the fullness or projection of one side accompanied by a corresponding flatness on the other. This is more noticeable when the patient bends the body forward so that the horizontal plane of the back is brought into view. (Fig. 70.) Corresponding changes, though of a less marked degree, appear on the anterior surface of the body, for example the apparent diminution in the size of the mamma on the side opposite the convexity of the posterior curve and its relative depression or elevation will usually attract attention.

It seems probable that a change in the antero-posterior contour of the spine precedes, in many instances, the lateral deviation. Thus a general droop of the body associated with round shoulders and a flattening of the chest, may be regarded as a predisposing cause or an early symptom of more serious deformity.

Mobility.—As has been stated, it may be assumed that habitual posture precedes actual deformity; habitual posture implies disuse of certain other attitudes and motions, thus limitation of the normal flexibility of the spine may be considered as one of the earliest signs of progressive deformity. The test of the motion of the different regions of the spine is therefore a necessary part of the examination. To test the motion in the lumbar region, one fixes the pelvis with the hands while the patient sways the body in the four directions and rotates it from side to side. It is suggested by Bradford and Lovett that direct lateral flexibility may be tested by placing blocks of wood under one foot, until the limit of flexion is reached, as shown by the inability of the patient to hold the elevated limb in the extended position. The experiment is then repeated on the opposite side. The flexibility of the upper part of the trunk may be tested by fixing the part below with the hands while the patient flexes, extends and rotates the body. It is important also to test the range of motion at the shoulder joints. The normal individual should be able to hold the arms extended directly above the head without increasing the lumbar lordosis. In many instances, however, it will be found that there is a marked restriction of this motion, in fact such restriction is almost always an accompaniment of so-called round shoulders.

The height and weight, the circumference and the expansion of the chest should be investigated, and a test of the muscular strength, not only of the muscles of the trunk but of the members as well, is of advantage as throwing light on the etiology and indicating the general line of treatment.

Record.—The most reliable of the graphic records to be used in connection with the history are photographs. The patient may stand behind a thread screen (Fig. 86) in the habitual attitude. The spinous processes, the iliac crests and the angles of the scapulæ having been marked with the flesh pencil, the exact amount of lateral devia-

tion of the trunk will be shown. The rotation may be indicated also by photographing the patient in the recumbent posture.

The rotation of the spine is the most important indication of deformity. This may be recorded with sufficient accuracy by taking direct tracings of half the trunk at fixed points by means of a lead or zinc tape while the patient lies in the recumbent posture.

At the Hospital for Ruptured and Crippled, the shadow of the trunk cast by an electric light at a fixed distance is traced upon a large sheet of paper. Upon this outline the position of the more important landmarks is indicated. The degree of rotation is shown by transverse tracings and the line of the spinous processes is ascertained by applying a broad strip of adhesive plaster to the back upon which the tip of each spinous process is marked.

Fig. 86.

The thread screen. From the Boston Children's Hospital Report.

Prognosis.—In the development of lateral curvature there is doubtless a preliminary or predisposing stage, a stage of progression and a stage of arrest. All deformities of this class are more likely to progress during the growing period. They are likely to become stationary when the period of growth is completed. Thus the prognosis is worse when the deformity begins at an early age than when it first appears in adolescence, especially if treatment is neglected or if it is inefficient. For example, some of the most extreme cases are caused by rhachitis, in which the deformity appearing in infancy or early childhood increases with the growth of the child.

If the causes of the deformity are such that they operate to check the equal development of the affected part, the prognosis is even more directly influenced by the age of the patient. For example, empyema, even if the lung is irreparably damaged, does not cause appreciable deformity in the adult, but in childhood the functional activity and the growth of the side of the thorax are checked, in addition to the direct effect of the adhesions and contractions due to the disease, thus the deformity is likely to be progressive in spite of the treatment. The same is true of paralytic deformity. In the ordinary type of lateral curvature in the adolescent girl, the prognosis is influenced of course,

by the general condition of the patient and by the character of the occupation. As far as the local deformity is concerned, the prognosis as regards improvement or cure depends in great degree upon the fixed changes that have taken place, and upon the degree of voluntary and involuntary rectification that is possible. In some instances the distortion of the body as apparent in the habitual posture may be considerable, yet the fixed deformity may be very slight, while in other instances the fixed rotation of the spine may be marked although the lateral distortion is hardly noticeable.

A single curve is more amenable to treatment than is a double or triple distortion, because it indicates an earlier stage of deformity and because the treatment may be more effective when applied to one deformity than to several. If, however, the single curve is fixed, the appearance of a secondary or compensatory curve at another part of the spine is probable, in spite of preventive treatment.

In the majority of cases, as has been stated, fixed deformity of the spine is already present when the patient is brought for treatment. This fixed deformity might be overcome doubtless in certain cases, and complete cure might be obtained, were all the conditions favorable. But in the ordinary sense a cure means the relief of symptoms, the checking of the progress of the deformity and the restoration of the general symmetry of the trunk. Such a cure may be obtained in most instances. The deformity of the spine becomes symmetrically divided on either side of the median line, the changes incident to maturity, particularly the increased amount of adipose tissue, serve to conceal the irregularities of the outline, and the history of the distortion is completed.

In certain instances, particularly in well-marked cases, the deformity may increase in adult life and even in old age; and in this class also the symptoms of discomfort and actual pain may be troublesome throughout life, especially in the overworked and debilitated class. The symptoms directly incident to the compression and distortion of the internal organs, have been mentioned.

The great majority of cases that develop or that are discovered in adolescence, progress for a time and come to an end on the cessation of growth, causing finally no symptoms other than the loss of symmetry that may be more or less perfectly concealed by the art of the dressmaker and by the corset.

It would appear then that lateral curvature of the spine is always of sufficient gravity to merit treatment and supervision until its cure or arrest is assured. If its discovery leads to active efforts to improve the general condition and to avoid unhealthful influences, it may even be of benefit to the patient.

Lateral curvature in a young child is of far greater importance because of the probability of an increase of deformity. Extreme deformity is always a source of weakness and usually of discomfort to the patient. Incipient deformity may be cured and cure is not impossible even when deformity is more advanced, but in this more than in any

other postural deformity, absolute cure implies early diagnosis and prevention, rather than the correction of fixed distortion.

Recapitulation.—It seems probable that in the ordinary type of lateral curvature of the spine, the first step is a change in the relation of the bodies of the vertebræ to one another; that a persistent lateral inclination and rotation of the anterior part of the column precedes the lateral inclination of the trunk which first calls attention to the deformity. This postural distortion becomes fixed by accommodative changes in the muscles and other tissues about the spine, and finally it is confirmed by changes in the shape of the vertebral bodies and by the general changes in the trunk as a whole. Thus if one might observe the inception and development of lateral curvature of the common type he would note, first, that the trunk was more often flexed to one side than to the other, and that this attitude gradually became habitual. Lateral inclination of the trunk necessitates of course lateral deviation and rotation of the bodies of the vertebræ and the habitual assumption of such a posture implies disuse of other postures and thus disuse of normal motion.

Disuse of motion in any direction is followed by diminished power in the inactive muscles, and as has been stated habitual deformity is followed by accommodative changes to a greater or less degree in the various tissues whose functions have been changed or modified.

Thus the progress of the deformity would be shown:

1. By the habitual assumption of an attitude simulating deformity.
2. By limitation of motion in the directions opposed to the habitual attitudes.
3. By fixed lateral deviation of the spine accompanied by rotation or twisting of the column.

One rarely has the opportunity to note the development of lateral curvature and when patients are brought for treatment fixed deformity is usually present. It is extremely difficult to entirely overcome fixed distortion, while it is comparatively easy to correct simple postural deformity in which the secondary changes are absent or but slightly advanced. On this account it is customary to divide lateral curvature into two classes, the *true* and the *false*, or to speak of rotary lateral curvature as distinct from lateral curvature. Thus the term true or rotary curvature would be limited to those cases in which the changes are fixed and in which cure is practically impossible, while false or simple or postural lateral curvature would include the early or curable class. But as the two forms are simply stages in the same process it would seem preferable to speak of the incipient and the later stages of lateral curvature, or of *reducible* or *irreducible* deformity, the distinctions that are made in classifying distortions of similar origin elsewhere.

This point of view is of advantage because it relieves the subject of much of the obscurity that has resulted from this arbitrary division. It emphasizes the fact also that the habitual assumption of an improper attitude that simulates deformity is the first step toward permanent dis-

tortion, particularly in individuals who are by inheritance or by constitutional tendency or by occupation predisposed to such deformity.

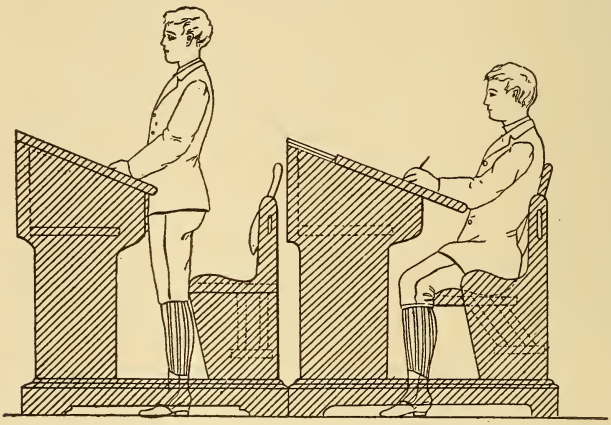
The Prevention of Deformity.—Prevention would include the avoidance of all the predisposing or exciting causes of weakness as well as of deformity. These it is hardly necessary to enumerate.

The first and most important preventive measure is the discovery of deformity or the tendency to deformity, at a time when it may be checked or cured. To discover deformity at this period of its development, one must look for it, and deformity in this sense would include not only fixed distortion, but improper attitudes and postures of every variety as well.

The importance of the attitude which is habitually assumed during occupation has been mentioned. Therefore, the provision of proper *desks and seats for school children* is a very essential part of preventive treatment.

The seat of the chair should be deep enough to support the thighs, yet it should not interfere with flexion at the knees. It should be of such height as to allow the feet to rest firmly on the floor, and it

FIG. 87.



Adjustable school desks and seats. Scheiber and Klein. (RÉDARD.)

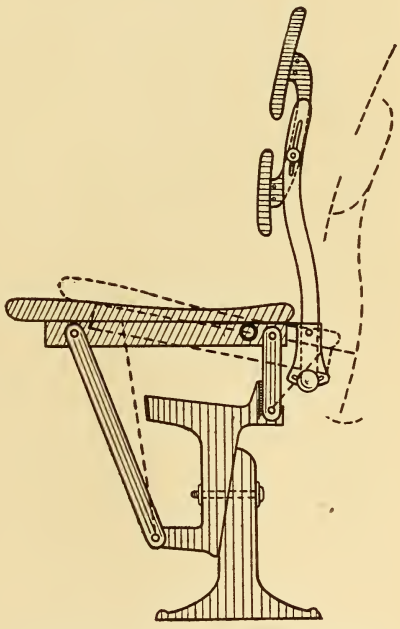
should be inclined slightly backward. The back of the chair should extend to about the level of the shoulders, it should be inclined slightly backward, but arched somewhat forward in the lumbar region in order to conform to the normal lordosis when the child sits in the erect posture. The desk should be as close to the body as is possible, so that the child need not lean far forward when reading or writing. The height of the desk should be slightly less than the level of the elbows when the child sits erect, and the inclination should be sufficient to hold the book at the proper distance from the eyes. The vertical handwriting is of advantage in that the children are taught to face the desk squarely, as contrasted with the lateral twist of the body, the usual attitude for writing. (Figs. 87 and 88.)

Treatment.—The treatment of rotary lateral curvature of the spine does not differ in principle from the treatment of any other weakness or deformity, but the application of this principle is much more difficult here than elsewhere, and the results are far less definite and satisfactory. This explains doubtless the apparently opposing theories and methods of treatment that are still advocated.

A brief account then of the rules of treatment as applied to weakness in general and of the exceptions that must be made in their application to curvature of the spine may be illustrated by comparing this deformity with another of similar causation.

One may take for comparison the weak foot, since the foot corresponds more nearly to the spine than does a simple joint, because of the number of bones of which it is made up. In the treatment of the weak foot one must first overcome all restrictions to passive motion, even by force if this be necessary. One next endeavors to strengthen the muscles that support the foot, by appropriate exercises, particularly those whose action is opposed to the habitual deformity. The avoidance of improper attitudes and of over-fatigue that favor deformity is also essential. Finally, if persistent deformity makes it evident that the voluntary or natural efforts of the patient are inefficient, a brace is employed to support the foot in proper position in order to aid the weakened muscles and to hold the joints in the normal position in which they may work to advantage. Under these conditions one would expect an immediate relief of discomfort and a progressive transformation of the internal structure of the foot, which in favorable cases would lead to complete cure of the deformity and of the weakness as well.

FIG. 88.



Adjustable school seat. (MILLER AND STONE.)

The principles of the treatment of any variety of weakness not directly induced by disease are then :

1. To overcome all restriction to passive motion.
2. To strengthen the weakened muscles, especially those whose action is opposed to habitual deformity.
3. To insist on the avoidance of over-fatigue and improper postures.
4. To support the weak part, if necessary, by a brace.

In applying these principles to the treatment of the distorted spine

the first step, the removal of restriction to passive motion in all directions, may be accomplished unless the deformity is of long standing, but this is difficult because of the variety of muscles and other tissues that may have become involved, and because the bodies of the vertebræ lying within the trunk, of which the distortion is always greater than the spinous processes, can be only indirectly affected by voluntary or by passive movements. The cultivation of the muscular system and particularly of those muscles whose action is opposed to the habitual deformity, is the second indication in treatment. As applied to the treatment of the weak foot in which the adductor and extensor muscles are at fault, this treatment is simple, but as applied to the trunk it is difficult because there are in nearly all developed cases two curves, the one primary and the other secondary; in direction directly opposed to one another. These opposite deformities are supplied in great part by the same muscles and it is difficult to straighten the convexity of one curve without at the same time increasing the concavity of the other. The third principle in treatment is the avoidance of predisposing attitudes and of overwork. This again may be more easily applied to the treatment of the weak foot; first because it is relieved from strain when the sitting posture is assumed and because active use, as in walking, may be utilized as an exercise for strengthening the muscles. But the muscles of the trunk are not exercised to any extent in ordinary walking, which is for many individuals the only form of activity, nor is the spine relieved from weight when the patient is seated. On the contrary it is in this restful attitude that the deformities of the spine are usually most marked. Thus only in the recumbent attitude is the spine entirely relieved from strain, and even at such times the deformities may be favored by the habitual attitudes of the patient.

Support of the weakened part by braces. The weak foot can be supported by a brace which in no way interferes with its activity, but which on the contrary makes movements free and normal by holding the bones in their proper relation to one another. But in the treatment of the spine the conditions are quite different, since the back cannot be supported without at the same time practically fixing it in one position, restraining its normal motion and compressing the muscles of the trunk. In other words the action of the support and the action of the muscles, instead of aiding one another, are almost directly opposed to one another; and finally no brace applied to the trunk is efficient, for while it may prevent the excessive lateral deformity it can exercise no direct action in overcoming the rotation of the spinal column. For these reasons braces except as temporary supports in cases under corrective treatment and in the hopeless class, are less in favor than in former times.

This comparative method of exposition has been adopted in order to demonstrate the fact that it is not the difficulty in formulating principles but the difficulty in applying them that makes the therapeutics of rotary lateral curvature of the spine perplexing. It is only by recog-

nizing the limitations of all systems of treatment as applied to this particular deformity and the necessity for selection and combination of methods that may be applicable to the particular case under treatment that one may arrive at satisfactory conclusions. Thus methods must be modified by the age of the patient and by a variety of other circumstances.

For example, in the treatment of *rhachitic scoliosis* in a young child one cannot count upon the voluntary assistance of the patient, therefore treatment by simple gymnastic exercises is impracticable. In this class of cases forcible correction of the deformity and retention by the use of apparatus, combined with massage, and the removal of superincumbent weight, would be the treatment of selection; for at this age the trunk is flexible and the deformity may be overcome, in part at least, by forcible manipulation. By progressive reduction of the distortion, followed by fixation of the trunk in the improved position one may expect at this period of rapid growth to induce a transformation of the deformed vertebral bodies to an approximation at least of the normal. In this class of cases the possibility of correcting the underlying deformity of the bones which must almost inevitably increase with the growth of the patient would quite outweigh the disadvantage of depriving the muscles of their normal stimulus during the corrective period of treatment.

In the *ordinary type of scoliosis* in older subjects, particularly if the distortion is moderate in degree and the changes in the bones but slight, one would expect to attain the best result by gymnastic training and by regulation of the postures.

The advisability of a change of occupation has been mentioned. It is probable that if the patient with incipient or even pronounced curvature of the spine were removed from school, were transferred to the country where during the succeeding years of childhood and adolescence much of the time might be passed in active exercise in the open air, the final result would compare very favorably with that attained by active treatment under less favorable surroundings. Such complete change of occupation and scene is of course impracticable in most instances. Lateral curvature of the spine is not a serious disease, it is simply an insidious distortion which rarely causes more than comparatively slight discomfort. It is usually overlooked in the incipient stage when it might be checked or cured, and when the deformity finally attracts attention it is usually no longer amenable to correction. Under these circumstances, with the uncertainty that exists as to the ultimate prognosis, the tediousness of treatment which cannot offer the assurance of definite cure, it is not strange that the affection is not one for the treatment of which any considerable sacrifice is considered essential.

A third class of cases would include the *fixed deformity in older subjects*, many of whom are obliged to assume in their occupations attitudes that predispose to deformity. In this class the use of a support to relieve discomfort and to prevent exaggerated distortion, may be indicated.

Thus there are three classes or types of scoliosis in which distinct methods of treatment may be indicated.

1. Curvatures in very young children, in which forcible correction and fixation would be the preliminary treatment, in the hope of correcting the deformity of the bones and curing the distortion.

2. The milder degrees of deformity for which treatment by exercises and if possible by favoring postures is the treatment of selection.

3. The third class would include fixed deformity in older subjects, as well as those cases caused by disease; as for example by paralysis, by empyema and the like, for which constant support might be indicated.

As a rule, however, no such distinction can be drawn. The treatment by exercises and by postures applies to all cases except in very early childhood, while support is indicated in a far more limited class.

Posture and Exercises.—Whatever may have been the original cause of the distortion of the spine and whatever may be its degree it is more marked when the patient is fatigued. Fatigue in the normal individual is shown by the increase in the normal antero-posterior curves; fatigue in the deformed subject causes an increase in the pathological curves. It requires far more muscular effort to hold the deformed spine in the best possible attitude than to hold the normal spine in the erect posture. Motion in the normal spine is as free in one direction as in another and it simply requires a proper balancing of the muscular force to hold it in the median line. Under the influence of fatigue it has no more inclination toward one side than the other unless the occupation or the attitude of the patient influences it. But when there is a fixed deformity, to overcome which, even in part, requires the conscious effort of the patient, it is evident that on the relaxation of this effort the spine will sink back into the habitual posture. The more confirmed the deformity the greater must be the effort to overcome it, and the more rapidly will fatigue be manifest. Fatigue, or rather the relaxation of conscious muscular effort, is favored by attitudes that do not require the balancing action of the muscles. For example, the sitting posture during school hours favors deformity, while the constant alternation of postures in work or play that requires muscular activity opposes it. Thus the selection of occupations, or at least the restriction of the time passed in inactive postures, is an essential part of treatment.

As improper attitudes are favored by weakness of muscles and as the maintenance of the best possible position requires a greater expenditure of muscular force than is required in the normal individual, the strengthening of all the muscles of the body, and particularly of those of the back, by gymnastic exercises, even beyond the normal standard, is the most important indication in treatment.

One of the most effective systems of treatment of lateral curvature is that advocated by Teschner, of New York. On the theory that lateral curvature is induced or that its development is favored by a general lack of muscular strength and lack of muscular control and coördination Teschner urges the necessity of the systematic cultivation

of all the muscles of the body as well as those of the trunk, the part particularly at fault. He also insists upon the importance of exercising each muscular group to the point of fatigue on the theory that a muscle cannot be developed to its full capacity unless it is thoroughly fatigued by uninterrupted automatic contractions and relaxations. The term automatic implies that the patient shall be so thoroughly trained in the rhythmical movements that they require no thought for their performance. Thus ease and grace may replace awkwardness and incoördination.

The system advocated by Teschner is modified from one taught by Attilla, a "trainer of strong men." It consists of a series of exercises with light dumb-bells and it is followed by so-called heavy work.

Fig. 89.

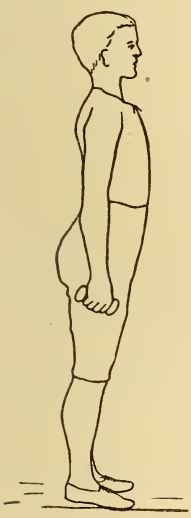


Fig. 90.

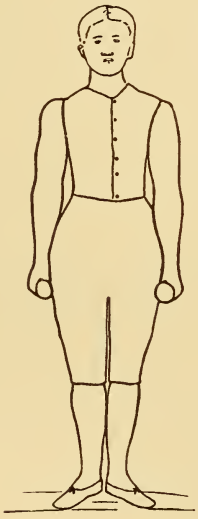
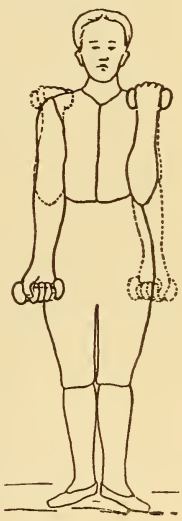


Fig. 91.



The exercises are designed for systematic cultivation of all the muscles of the body, the heavy work more directly for the correction of the deformity of the spine.

General Exercises.—The exercises should be performed before a mirror, the patient being clad in a close-fitting rowing suit so that the attitudes may be constantly observed by the patient and by the instructor. The greatest attention is paid to the perfection of the alternating movements of the limbs in order that they may become in time purely automatic in character. During the performance of the exercises the patient holds himself in the best possible position.

These exercises were described and illustrated by Teschner in the *Annals of Surgery* for August, 1895, from which they are, with his permission, reproduced.

"A pair of dumb-bells, weighing from one-half to five pounds each, according to the ability of the patient, is used in a series of twenty-six exercises.

THE EXERCISES.—The patient stands erect, the heels together, the toes apart, the knees thoroughly extended, the abdomen retracted, the

FIG. 92.

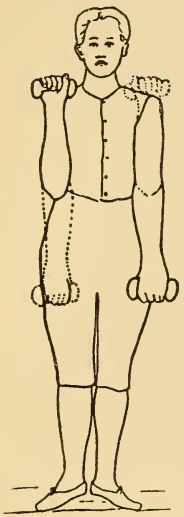
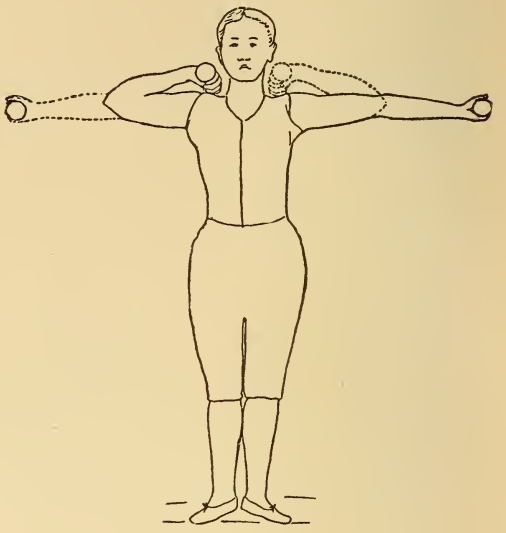


FIG. 93.



chest high, the head well poised, and the patient looking intently and sharply into his or her own eyes in the mirror, the lips being evenly, but not too firmly, closed, and the facial muscles in repose. The pa-

FIG. 94.

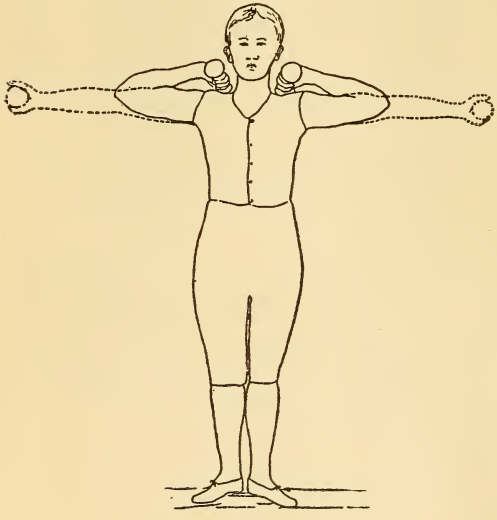
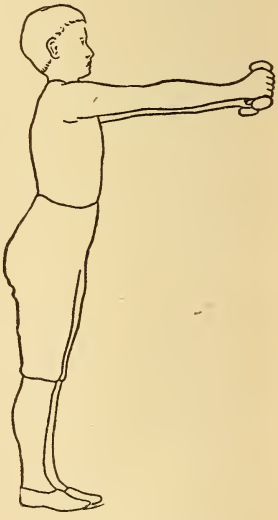


FIG. 95.



tient should breathe easily and regularly while exercising. (Figs. 89 and 90.)

"1. The upper extremities are fully extended downward, the forearms supinated, the elbows remaining close to the sides of the body, and the upper arms being fixed; the forearms are alternately and automatically fully

Fig. 96.

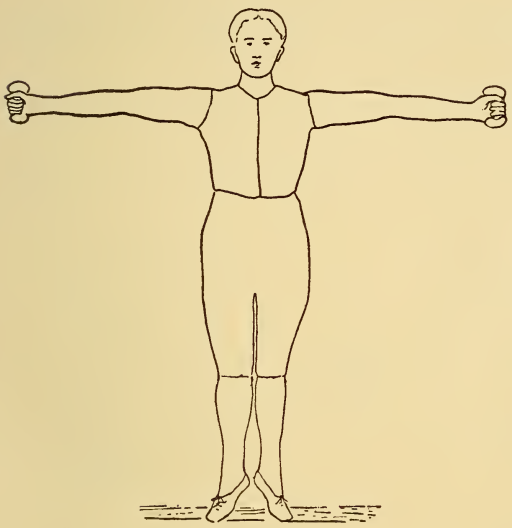
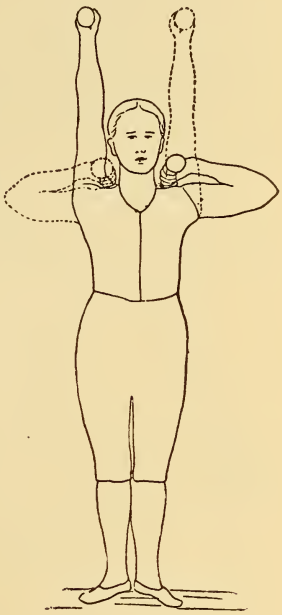


Fig. 97.



flexed and extended, the wrists and entire body being fixed and immovable. Twenty to fifty times. (Fig. 91.)

"2. The same position and exercise, except that the forearms are

Fig. 98.

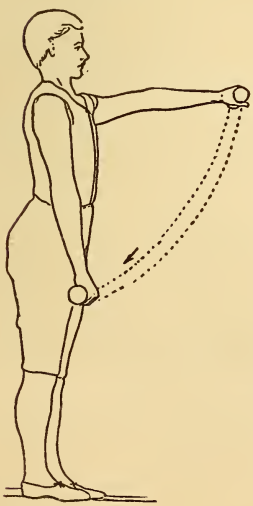
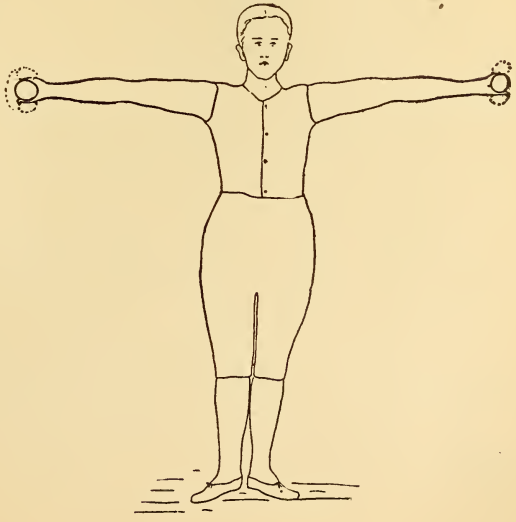


Fig. 99.



fully pronated, and remain so during alternate flexion and extension. Twenty to fifty times. (Fig. 92.)

"3. Both bells over the shoulders, the arms abducted at right angles to the body and in the same vertical and horizontal planes, the forearms fully flexed upon the arms, and the wrists fully flexed upon the forearms. The forearms and wrists are then alternately and automatically extended and flexed. Ten to twenty times. (Fig. 93.)

"4. The same position and exercise, except that both upper extremities are flexed and extended at the same time. Five to fifteen times. (Fig. 94.)

"5. Both upper extremities fully extended forward on a level with the shoulders, the dorsum of the hands outward. They are then fully and forcibly abducted on a horizontal plane, the patient at the same time raising body upon the toes, and are then permitted to re-

Fig. 100.

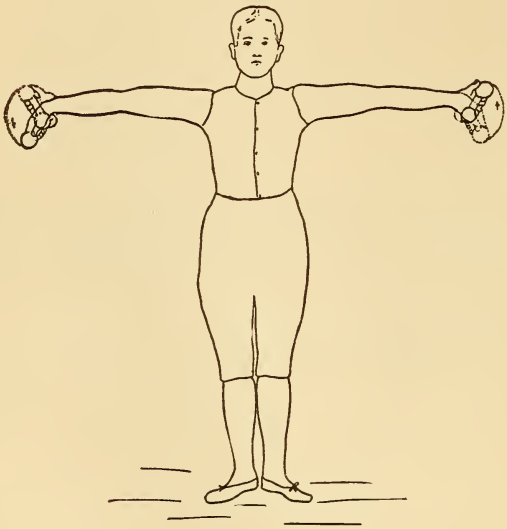


Fig. 101.

cede to the original position, the body resting on the toes and heels, the elbows and wrists still rigid, the bells not being permitted to touch as they approximate each other. Five to ten times. (Figs. 95 and 96.)

"6. Bells in the position of exercises No. 3 and No. 4. The arms are fully extended alternately above the head. Ten to twenty times. (Fig. 97.)

"7. Bells in front of the thighs, forearms pronated, and bells alternately raised to the level of the shoulders, the elbows and wrists being fixed. Ten to twenty times. (Fig. 98.)

"8. The arms abducted at right angles to the body, the bells rotated rapidly and forcibly forward and backward, the elbows being fixed. Five to ten times. (Fig. 99.)

"9. The arms abducted at right angles to the body, the thumbs upon one ball of each bell, the hands circumducted forward from above downward, the ball upon which the thumbs rest describing circles, the elbows and shoulders being fixed. Five to ten times. (Fig. 100.)

"10. The same as No. 9, the hands being circumducted backward. Five to ten times. (Fig. 100.)

"11. The bells to the side. Right face upon left heel, then placing the left foot at right angles to right foot opposite the arch, the knees slightly flexed, the right hand at waist-line against the body, the bell

FIG. 103.

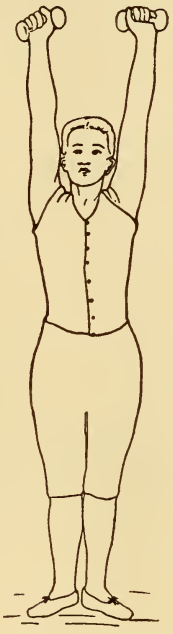


FIG. 102.

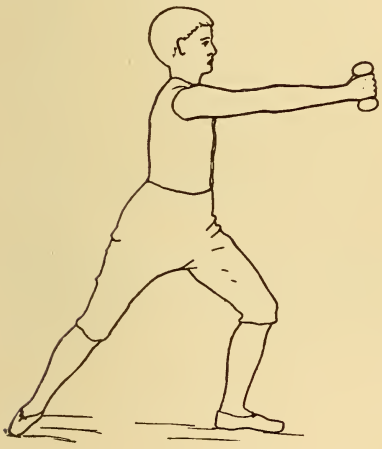
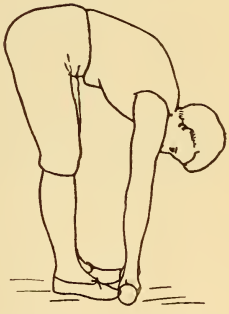


FIG. 104.



being perpendicular. Second part of motion: strike from the shoulder to level of the face, advancing a step upon the left foot, rapidly extending the right thigh and leg, the right foot being fixed upon the floor, and quickly back to position. Ten to fifteen times. (Figs. 101 and 102.)

"12. Exactly the reverse of No. 11. Ten to fifteen times.

"13. Bells extending above the head, palmar surfaces looking forward, bending down to the floor, the knees remaining extended, and return. Five to fifteen times. (Figs. 103 and 104.)

"14. Bells downward at the sides, raising and dropping the shoulders. Ten to twenty times. (Fig. 105.)

"15. Bells downward at the sides, flexing the spine laterally, first to the right and then to the left. Ten to twenty times. (Fig. 106.)

"16. Both arms extended forward to about forty-five degrees and abducted at about the same angle, then forcibly crossed in front of the

chest, causing the pectoral muscles to contract vigorously, the elbows and wrists being fixed, and then back to the original position. Five to twenty times, alternating the right and left hands above. (Fig. 107.)

Fig. 105.

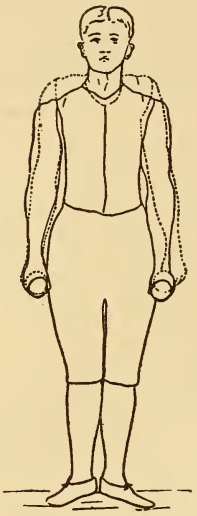
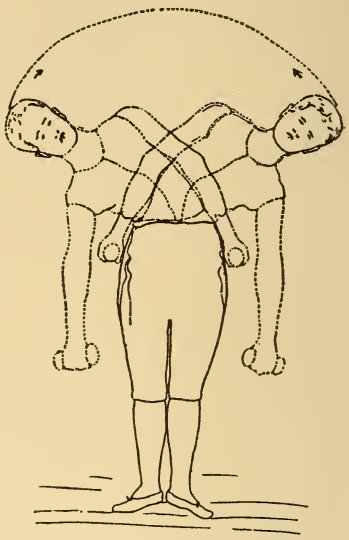


Fig. 106.



"17. Bells at the sides, palmar surfaces looking forward. Extend arms backward in a vertical plane as forcibly as possible, holding them rigid in the fully extended position for a few moments, and then re-

Fig. 107.

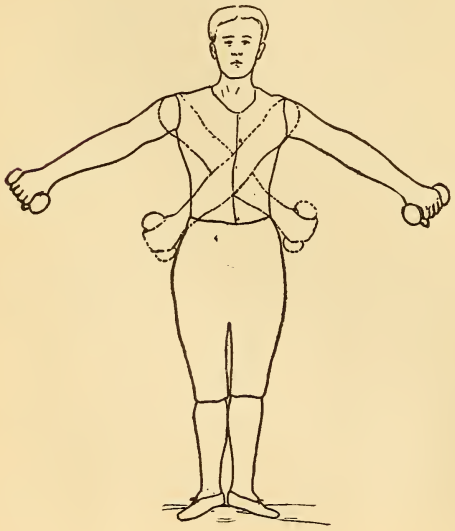
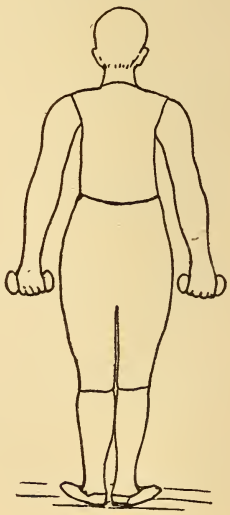


Fig. 108.



turning the bells to the sides. Five to fifteen times. (Figs. 108 and 109.)

" 18. Bells to the sides. Raise the body upon the toes and sink to original position. Ten to twenty times. (Fig. 110.)

" 19. Same position. Raise the toes as far as possible from the floor,

Fig. 109.

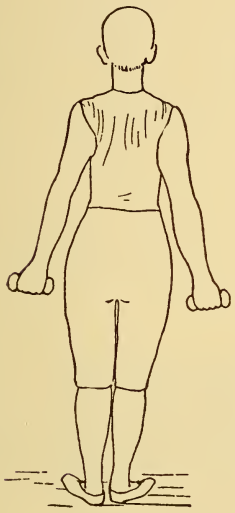
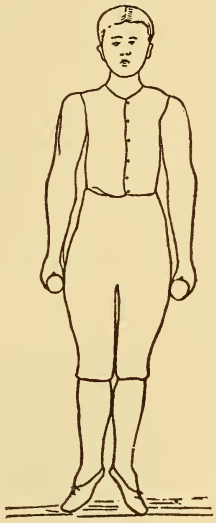


Fig. 110.



the body remaining erect. Ten to twenty times. (Fig. 111.)

" 20. Same position. The patient squats, abducting the knees and resting upon the toes, the heels being raised, the trunk perfectly erect, then resuming first position. Five to twenty times. (Fig. 112.)

Fig. 111.

Fig. 112.

"21. Same position. Standing upon left foot. Flexing the right thigh to a right angle to the body extending the knee and ankle fully. The patient squats on the left ham, the left heel remaining on the floor,

Fig. 114.

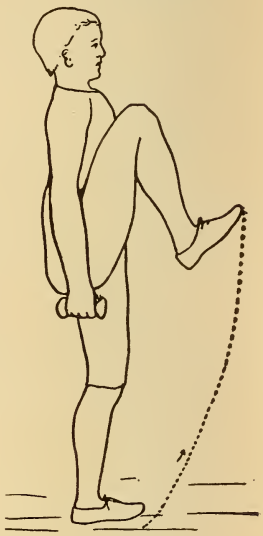
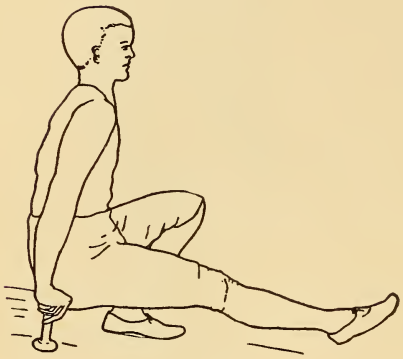


Fig. 113.



and then resumes the first position. Two to five times. (Fig. 113.)

"22. The same standing upon the right foot. Two to five times.

"23. The same position. Alternately and forcibly flexing the thighs

Fig. 115.

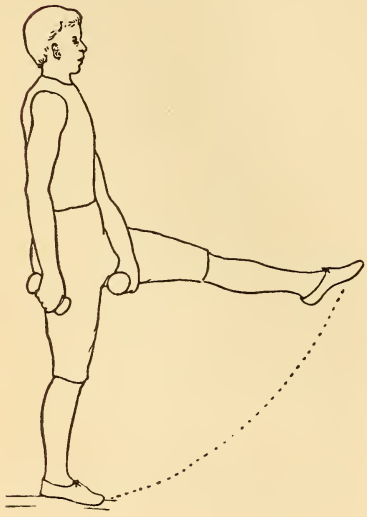
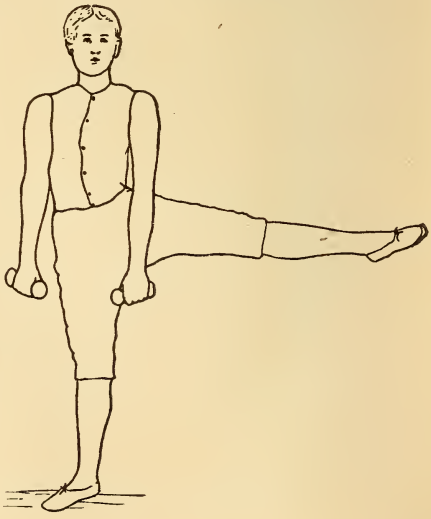
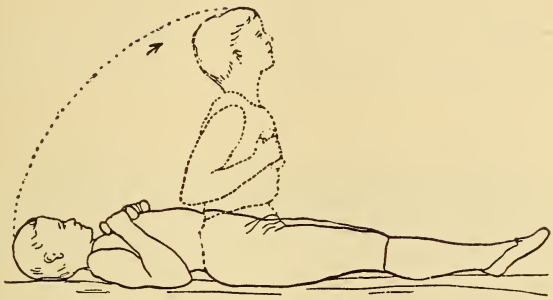


Fig. 116.



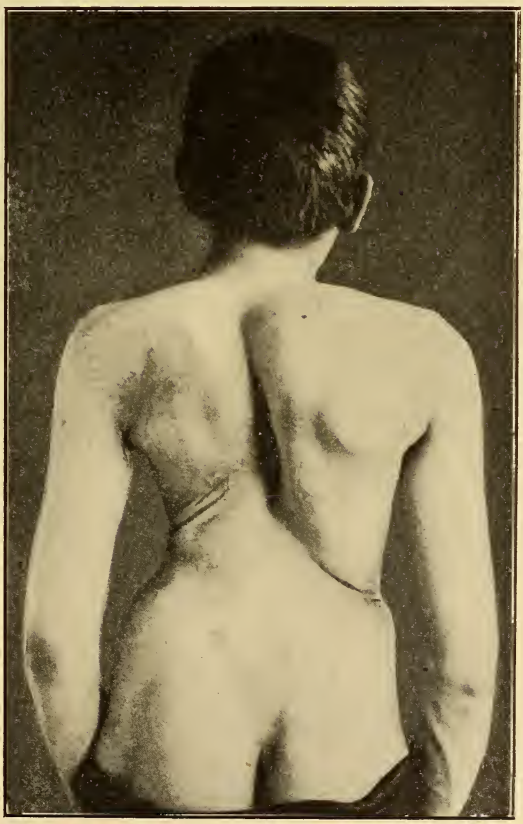
and legs, causing the knees to touch the shoulders. Ten to twenty times. (Fig. 114.)

Fig. 117.



"24. The same position as in No. 21, extending the right lower extremity, the right bell inside the thigh, the right foot moved in a cir-

Fig. 118.



Scoliosis of an advanced type accompanied by dyspnœa and cyanosis. (Teschner.)

cle on a horizontal plane to complete extension backward, and resuming the first position. Two to five times. (Figs. 115 and 116.)

"25. The same as No. 24, standing upon the right foot. Two to five times. (Figs. 115 and 116.)

"26. The patient lying supine upon the floor, the lower extremities fully extended, the bells resting upon the chest, then raising the trunk

FIG. 119.

The same patient swinging 30-pound bell, showing the muscular development. (TESCHNER.)

to the sitting position, the lower extremities remaining extended, and the eyes being fixed upon the ceiling, and returning to the original position, touching the back of the head only on the floor, thus the hyperextension of the spine is maintained. Five to twenty times. (Fig. 117.)

"When the patient has become proficient in these exercises, they should be done at home every morning and evening.

"THE HEAVY WORK.—Bells, weighing from five to eighty pounds each, and steel bars and bar-bells, weighing from twenty-six to over one hundred and eleven pounds, are used in different ways. Bells are pushed from the shoulders above the head alternately as often as the patient is able. (Fig. 119.)"

"The patient is instructed to swing a heavy bell with one hand from

FIG. 120.

The patient pushing 25-pound bells; the right arm up. (TESCHNER.)

FIG. 121.

The patient pushing 25-pound bells; the left arm up. (TESCHNER.)

the floor above the head and down again, the elbow and wrist being fixed, and the motion repeated as often as possible in a systematic manner; then with the other hand the same number of times, and later with both. This exerts all the extensor muscles from the toes to the head in rapid succession.

"When a heavy bell is pushed or swung above the head on the side

opposite the scoliosis, the action of the back muscles, to sustain the weight and equilibrium, is such as to cause the curved spine to approximate a straight line. (Fig. 121.) A similar result is produced when a heavy weight is held by the side of the erect body on the scoliotic side, the arm being at full length.

"When a heavy bar is raised above the head with both hands, the patient must fix the eyes upon the middle of the bar to maintain an equilibrium. This necessitates the bending of the head backward, the straightening and hyperextending of the spine, and consequently correcting a faulty position with a weight superimposed. The heavier the weight put above the head, whether with one hand or with two, the more the patient must exert himself or herself to attain and maintain a correct or an improved attitude in order to sustain the equilibrium. (By an improved attitude I mean the greatest amount of correction of the deviation of the spine that the fixation of a deformity will allow of.) Hence, the greater the weight, the more forcible the actions of the muscles become, and the greater the temporary reduction of a deformity. It is by means of frequent and forcible temporary reductions of deformities, by voluntary muscular action, that we can hope to improve, and do improve, those cases which are amenable to any form of active treatment.

"When a patient, lying supine upon the floor, raises a heavy bar above the head so that the arms are perpendicular to the floor, the weight of the bar, the position and weight of the body, and the action of the muscles tend to broaden the entire back and shoulders, and a slow downward movement tends to widen the entire chest, and most markedly at the shoulders. The frequent repetition of the upward and downward movement plays an important part in the rapid development of the chest and back. Pushing the bells above the head, swinging them with each hand separately and with both hands together, raising a bar above the head, standing and lying down, and the exercises before enumerated, constitute one day's work.

"As the amount of work performed by a patient depends upon the last previous record of that patient, that record must be improved upon at each succeeding visit, unless there be a good and sufficient reason to the contrary. Most patients can well stand three treatments a week. (Vide table.) In mild, habitual cases improvement in deportment is noticed by the patients' relatives and friends and by the patients themselves within the first two weeks. In those cases two months' treatment usually suffices to effect a complete cure. In the more severe cases it is not and can not be expected to attain such rapid results, but a certain appreciable improvement is effected, and the amount of improvement depends upon the persistent continuance of the treatment. When there is a fixed rotation of long standing, with bony and ligamentous changes, the prospects are not so good; but even in those cases considerable improvement will be evident.

"Patients are not permitted to wear supports of any kind, not even corsets. They should not exercise until at least two hours after a

meal, nor when menstruating. The general health is improved by the exercises; the patients gain in height and weight. The girths and breadth measurements, chest depth, strength tests, and lung capacity are generally increased, and the depth of the abdomen is usually decreased. In some cases, especially those of undersized patients, the increase in height is very rapid, and it is certainly more than the increase by ordinary growth. There were marked cases of flat foot which were benefited. The flat feet became shorter through the exercises by the increase in depth of the inner arches."

RECORD OF THE WORK PERFORMED BY A GIRL 14 YEARS OF AGE. (TESCHNER.)

DATE.	REGULAR EXERCISES.	PUSHING.	SWINGING WITH EACH HAND.	SWINGING WITH BOTH HANDS.	PUSHING.	FIFTY-POUND BAR ABOVE THE HEAD.	
1895.	Bells.	Two 10-lb. Bells.	One 15-lb. Bell. R.—L.	Two 15-lb. Bells.	Two 20-lb. Bells.	Standing.	Lying Down.
April 6.	3 lbs.	.....	.....	.....	.....	.....	.....
" 9.	"	100	10—10	5	.....	Instructed.	Instructed.
" 11.	"	150	25—25	15	10	2	5
		2 15-lb. bells.	1 20-lb. bell.				
" 13.	"	50	25—25	25	12	5	10
" 16.	"	54	30—30	35	18	7	12
" 18.	"	60	35—35	40	20	7	15
			1 25-lb. bell.	2 20-lb. bells.			
" 20.	"	70	20—20	20	30	10	15
" 25.	"	90	22—22	25	33	15	16
" 27.	"	100	35—35	30	50	17	20
" 30.	"	110	50—50	35	60	20	22
May 2.	"	120	60—60	36	70	20	25
			1 30-lb. bell.		2 25-lb. bells.	64-lb. bar.	64-lb. bar.
" 4.	"	140	20—20	40	25	5	10
" 7.	"	150	25—25	45	30	7	12
" 14.	"	160	27—27	50	34	9	13
" 16.	"	170	30—30	55	40	10	14

This method combines the forcible correction of deformity by means of the "heavy work" with muscle building. It has the merit also of making an immediate mental impression upon the patient which no other system can make; for if the patient does not "strain every nerve," he must certainly exercise every muscle, to preserve the equilibrium while supporting the heavy weights, and this mental impression is undoubtedly one of the important elements in successful treatment.

The system has the disadvantage, if disadvantage it may be called, of making class work impossible, for the patient must be under constant supervision, not only that he may be urged to the limit of his capacity, but that over-strain may be avoided as well.

It might appear from the description that the danger of over-work is great, but in a long series of cases, some of which were complicated by defects of the heart and lungs, no unfavorable symptoms have been observed by Teschner. The system is, however, one that can only be practiced by a physician.

Another system of exercises is that followed at the Hospital for Ruptured and Crippled. Dr. Truslow has been kind enough to outline for me some of the more important exercises and to illustrate them with the photographs that are reproduced here.

The objects of the treatment are: (1) To overcome the patient's faulty habits of posture by the repeated purposeful assumption of proper postures; in other words, to counteract the deformity habit by training the mental and muscular perception of symmetry. (2) To stimulate and to strengthen the weakened muscles, particularly those muscular groups that are especially concerned in overcoming the deformities, and which, for the present purpose, may be considered as weak.

For convenience of description the exercises are divided into two classes: (1) Self correction; (2) Muscle building.

Self Correction, Postures.—The first exercises (*a* and *b*) in self correction are for the purpose of overcoming the antero-posterior deformities that usually accompany lateral deviation of the spine.

(*a*) *Head Bending Backward.*—In this exercise the chin is not tilted upward, but, the head being held level, the neck is drawn directly backward until the cervical and upper part of the dorsal segments of the spine are completely extended. Thus by increasing the distance between the points of attachment of the sterno-mastoids and the scaleni, strong traction is made upon these muscles with the effect of elevating the upper part of the thorax, an important feature in the exercise.

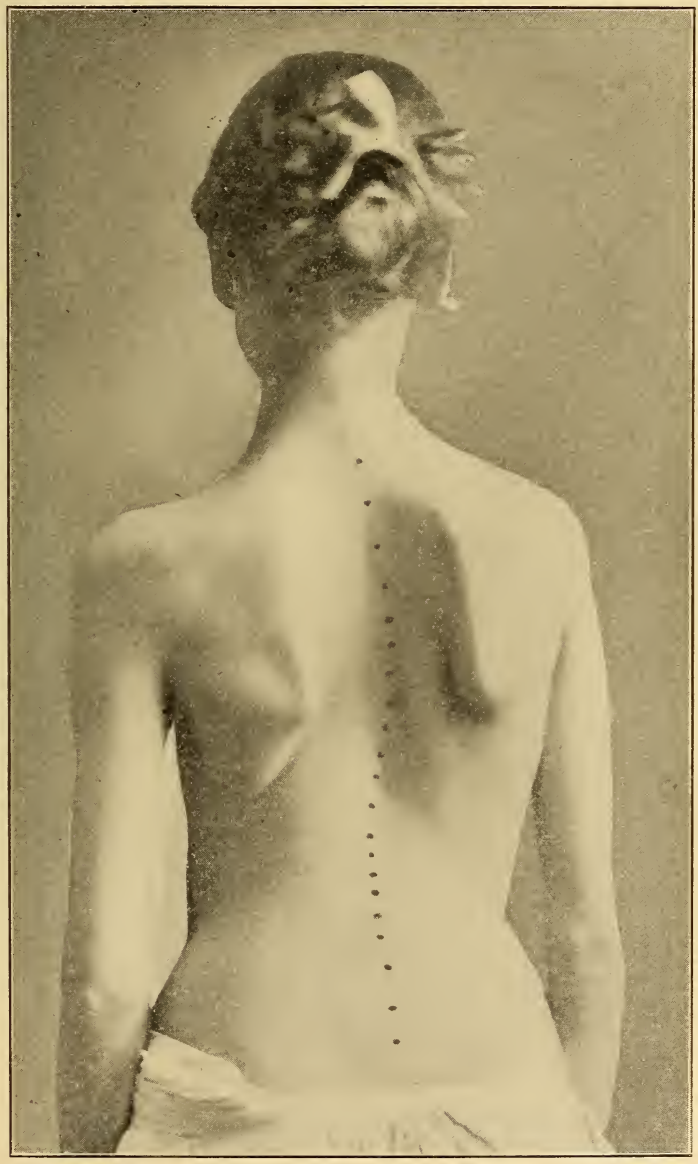
(*b*) *Trunk Bending Forward and Trunk Raising.*—The patient stands in the erect posture with the spine extended and the chest expanded as in the previous exercise. The trunk is then bent forward (similar to Fig. 127), the only motion being at the hip joints. The trunk is then raised again to the former position, care being taken to keep the hips farther back than the chest. In both flexion and extension the spine must be rigidly held in the corrected attitude and there must be no motion at the knees. There is, of course, a movement corresponding to extension at the ankle joints when the legs and buttocks are thrown backwards to compensate for the forward bending of the body. The object of this exercise is to train the patient to keep the hips back and the chest forward.

The other exercises in self correction are for the purpose of overcoming lateral deviation of the spine, the right dorsal, left lumbar curve, with the high right shoulder and the prominent left hip, being taken as a type. (Fig. 122.)

This series is arranged in a progression, and each one must be learned before the next in order is attempted.

(c) *Left Neck Firm.*—The left hand is placed behind the neck, the left shoulder is raised and the left elbow is held well back. This pos-

FIG. 122.

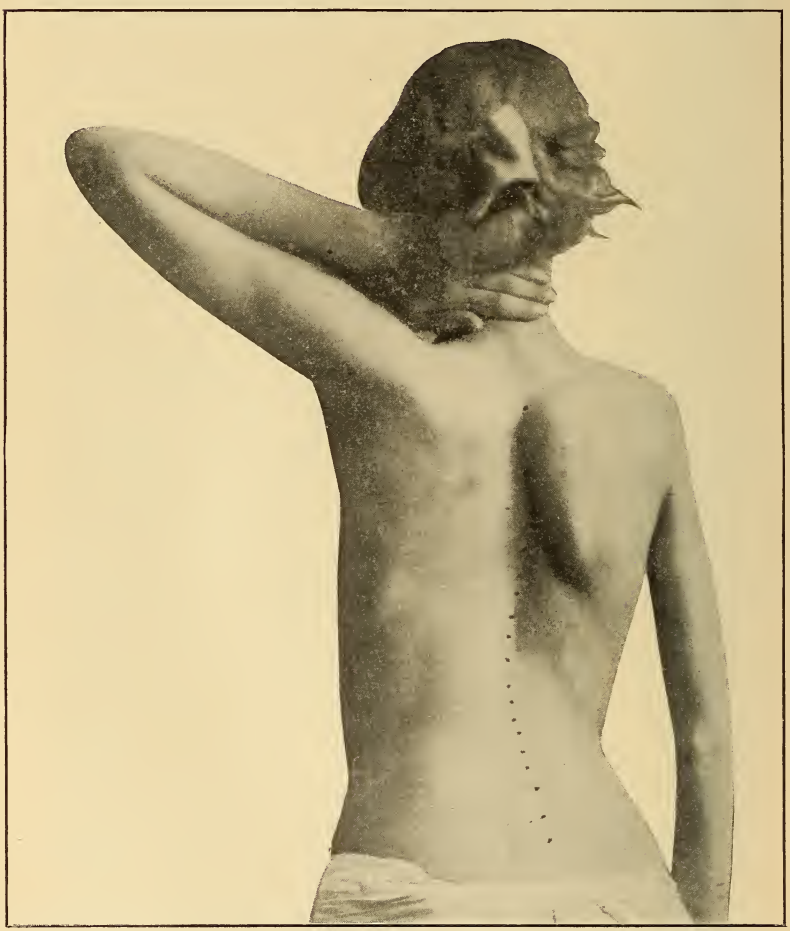


Typical lateral curvature. Right dorsal. Left lumbar.

ture impresses upon the patient the necessity of approximating the left shoulder and the neck. (Fig. 123.)

(*d*) *Body Inclination to the Left.*—This is a most important posture; it is intended to correct mechanically the faulty inclination to the right and to overcome the upper curve by traction on its concavity. The patient holding the arm in the first position is instructed to stretch well out with the left elbow, rotating upward and abducting the left

FIG. 123.



Left neck firm.

scapula as much as possible. This puts upon the stretch the rhomboidei and the lower half of the trapezius of the left side, thus making strong traction upon their points of attachment in the dorsal concavity. At the same time the patient is directed to sway the pelvis to the right. This usually requires assistance at first, for it brings

into action certain deep back muscles, over which one has ordinarily but little control. The shoulders must be kept level and the proper relation of the head and neck to the left shoulder must not be disturbed in this forced stretch to the left. (Fig. 124.)

(*e*) *Chest Pressing with the Right Hand.*—The patient holding the left arm in the first position presses the right hand firmly against the

Fig. 124.

Body inclination to the left.

dorsal convexity. This posture may be employed to advantage if there is a long right dorsal curve, when it is an efficient aid to the left-sided pull of the two former exercises.

(*f*) *Right Neck Firm.*—The right hand is placed behind the neck, without, however, disturbing the improved position induced by the first exercises. With both hands placed behind the head, the arms

being in a symmetrical position, there is better mechanical fixation of the head, neck and upper part of the trunk during the next exercise. (Fig. 125.)

(*g*) *Left Hip Twisting Backward.*—In posture (*d*) the pelvis was swayed slightly to the right; it is now twisted slightly backward on the left side to overcome the twist in the lumbar spine which usually throws this side of the pelvis somewhat forward. This correcting

FIG. 125.

Right neck firm.

motion should be carried out in the lower dorsal and lumbar segments and it should not affect the attitude of the remainder of the trunk.

(*h*) *Left Oblique Stride Standing.*—The pelvic twist and right-sided sway being rigidly maintained, the left foot is placed about two foot-lengths forward and a little outward. Upon this leg the greater part of the weight of the body is now supported. This allows a slight downward tilt of the pelvis to the right, and lessens the left lumbar convexity. (Fig. 126.) The positions, attained by the progressive

exercises to this point, being maintained, the patient continues with

(*i*) *Trunk Bending Forward.*—In this posture, motion takes place

Fig. 126.

Left oblique stride standing.

in the hip joints only, as in the first exercise. This exercise further emphasizes the symmetrical position of the head and neck, the left-

sided inclination of the upper half of the trunk, the right-sided inclination of the lower half, the twist and downward tilt of the pelvis. (Fig. 127.) The return to the improved standing position should be made in this order: (1) Trunk raising; (2) Replacement of the left foot; (3) Return of both arms to the sides. This is done slowly and carefully by the patient, who attempts to maintain the improved posture.

FIG. 127.

Trunk bending forward.

The postures constitute a progression which cannot be learned in less than seven treatments; often much more time is required. As each part is learned, it should be practiced at home until the next treatment, when a new posture is added, if it appears that progress can be made.

These successive postures are in reality exercises in that it requires constant muscular effort to retain them, but they are not exercises in the sense of repeated alternations of position. The series is simply an elaboration of what is called the keynote posture. The raising of the left elbow, for example, makes it easier for the patient to overcome the distortion of the upper part of the spine ; it also instructs him in the manner of holding the spine in the improved position after the arm is placed by the side. The same is true of all the postures ; each one suggests and makes correction easier, and after sufficient practice the patient should be able to assume the corrected position without placing the arm or the leg in the preliminary attitude. Thus the successive postures are, as it were, letters, which, placed together one by one, make a complete word, or the best possible position that the patient can assume. At first the patient must use the letters and slowly spell out the corrected attitude, but after the muscles have been educated by the repeated assumption of each posture, and when the perception of symmetry has been acquired, the corrected attitude may be assumed at will, and, in part, at least, instinctively retained at all times.

Muscle Building, Exercises.—In the treatment of lateral curvature one aims to strengthen :

1. The posterior cervical muscles.
2. The dorsal and lumbar muscles.
3. The muscles of vertebro-scapula attachment.
4. The abdominal muscles.
5. The thigh and leg muscles.
6. The chest-expanding muscles.

The following exercises have been selected as best adapted for this purpose. Each one should be performed five or more times according to the strength of the patient.

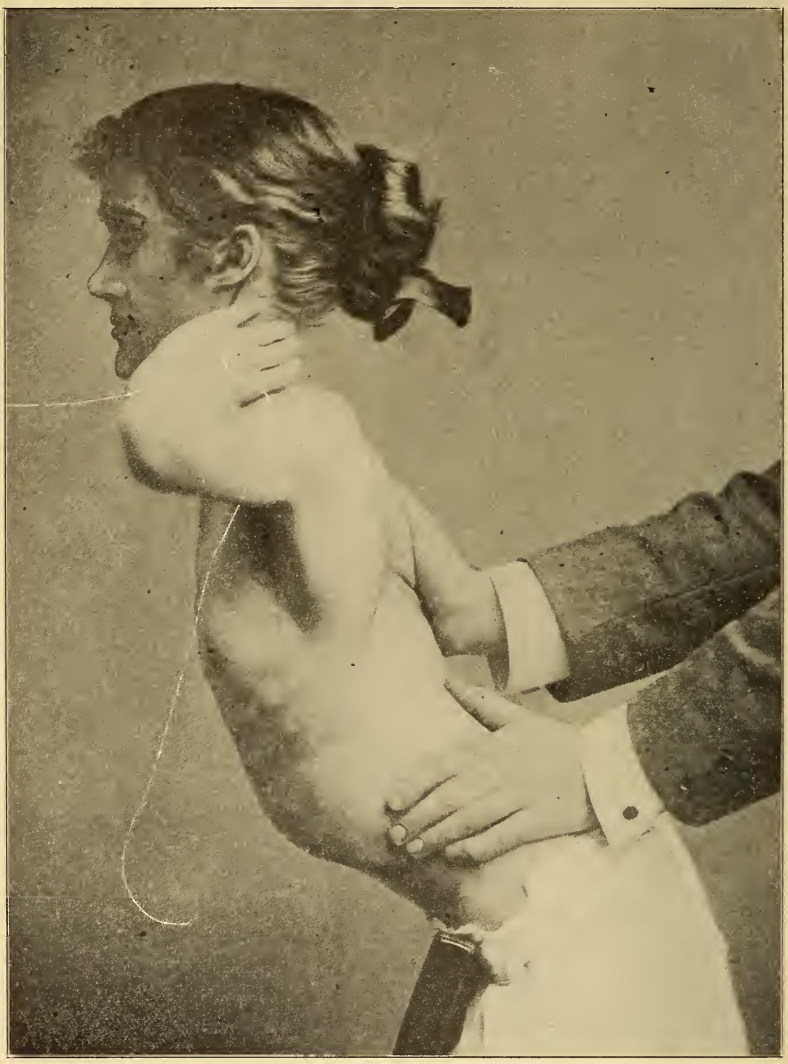
(*a*) *Opposite Standing, Head Bending Backward, Resisted.*—The patient stands before a wall or a shoulder-high horizontal bar on which the hands are placed with the arms extended. The head is bent forward and is then forced backward, the latter movement being resisted by the hand of the surgeon. This exercise is designed to strengthen the posterior cervical muscles.

(*b*) *Opposite Bend Standing, Trunk Raising, Resisted.*—The patient stands with the upper part of the thighs in contact with a table or horizontal bar. The hands are placed behind the neck and the body is bent forward on the hip joints as in the first exercise. The surgeon standing behind places his right hand over the posterior dorsal prominence and his left over the lumbar projection. The patient then raises the trunk to the erect position against the combined resistance. (Fig. 128.) With a little practice the surgeon learns to give an outward twisting motion to his hands while resisting, which tends to untwist the spinal rotations. When the dorsal rotation to the right is marked this untwisting may be facilitated by encircling the patient's chest with the left hand while with the right, strong forward and out-

ward pressure is made as the patient raises the body. This exercise is for the purpose of developing the muscles of the erector spinæ group.

(*c*) *Prone Lying, Head and Shoulder Raising "The Seal."*—The

FIG. 128.



"Opposite bend standing." Trunk raising resisted.

patient lies upon a table or upon the floor, and raises the head and chest—"looks at the ceiling." Progression is made in the increased leverage of arm-weight transference.

1. With the hands on the backs of the thighs.

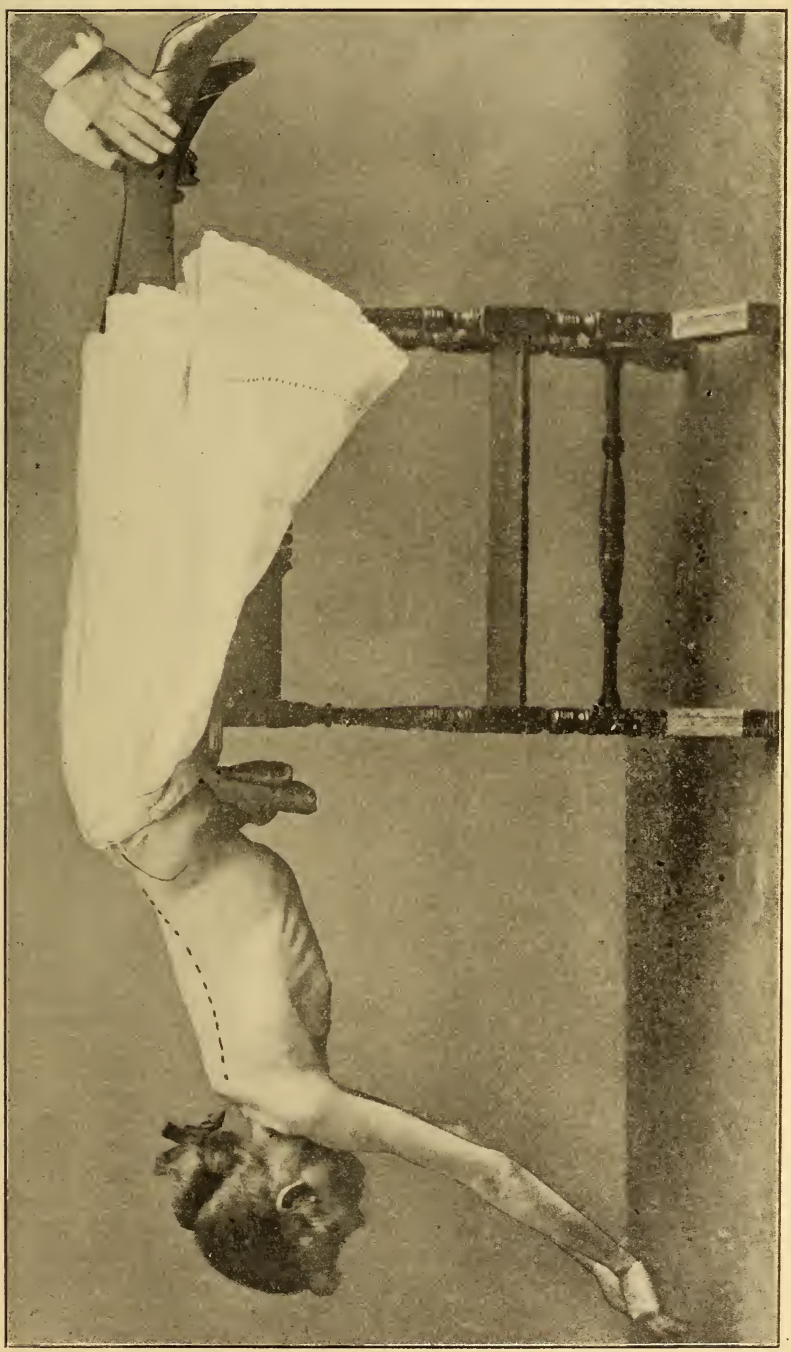


FIG. 129.

"Prone lying," "diving."

2. With the left hand behind the neck and the right hand on the back of the thigh.

3. With both hands behind the neck, and with the elbows well out and back.

4. "Swimming." The arm motions of swimming, in three counts. This exercise is to strengthen the muscles of the back from the head to the pelvis.

(*d*) *Prone Lying, "Diving."*—The patient lies upon a table, the trunk and pelvis projecting beyond its edge, the limbs being fixed by a strap or by the weight of another person. The body is then bent downward and is raised again to the horizontal position. (Fig. 129.) In this exercise, assistance will be required at first. Progression is made by transference of arm weights, as in the former exercise, thus:

1. With the hands on the hips.
2. With the arms stretched out at right angles to the body.
3. With the hands behind the neck.
4. With the arms extended in the line of the body.

This exercise is for the purpose of strengthening all the muscles of the back.

(*e*) *Prone Lying, Leg Raising.*—The patient, lying in the prone posture upon the floor or table, lifts the limbs (over-extends) alternately, the raised leg being held perfectly straight. When the left thigh is extended, as much as the ilio-femoral ligament will allow, the left side of the pelvis is tilted upward also, thus untwisting the lumbar spine. Progression in this exercise is made as follows:

1. Alternate leg raising, unresisted.
2. Alternate leg raising, resisted.
3. The leg motions of swimming, in three counts.

In this exercise the entire lower extremities must project beyond the supporting table. The exercises are for the purpose of strengthening the lumbar muscles and the extensors of the thigh.

(*f*) *Opposite Sitting, Backward Bending of the Trunk.*—The patient is seated upon a bench, and the feet are fastened to the floor. The trunk being held in a position of complete extension is bent slowly backward, motion being at the hip joint only. Progression.

1. With the hands behind the hips.
2. With the left hand behind the neck, the right hand on the hip.
3. With both hands behind the neck.
4. With both arms extended upward.

At first the body is bent backwards about forty-five degrees, later until the head touches the floor. This exercise is to strengthen the abdominal muscles.

(*g*) *The Horizontal Bar. "Pull-ups."*—The patient hangs by the hands and is assisted to "chin the bar." The body is then allowed to sink slowly back into the former position, the elbows are held well back, and the patient is instructed to bear as much of the weight as is possible with the left arm and shoulder. This exercise corrects the dorsal curve by means of muscular activity, and the lumbar curve by

the weight of the suspended pelvis and limbs. The muscles used are those with vertebro-scapula attachment.

(*h*) *Left Leg Standing, Pelvis Tilting.*—The patient stands upon the edge of a bench, supporting the weight on the left leg, the right leg being suspended beyond the side of the bench. While the head and trunk are kept in the corrected position, the pelvis is made to tilt sharply downward on the right, by lowering the right leg, while the left is kept perfectly stiff. This has the effect of straightening the lumbar curve.

(*i*) *Left Leg "Hopping."*—Both hands are placed behind the neck and the weight is supported entirely upon the ball of the left foot. In this attitude the patient hops ten or more times. This exercise, like the last, tends to straighten the spine and to strengthen the muscles of the left leg, which are often somewhat weakened from disuse.

(*j*) *Respiratory, Half Reclining, Arm Extensions and Flexions, Resisted.*—The patient sits in a chair with an inclined back, or lies upon a low table with hard pillows under the mid-dorsal region, so that the upper dorsal and cervical segments of the spine must be over-extended. The arms are stretched upward and backward, and the hands are grasped by the surgeon, who stands behind and resists the patient's downward pull. With the upward stretch of the arms and pull by the surgeon, the patient inhales forcibly. With the downward pull against resistance, the patient exhales forcibly. This exercise is made in the rhythm of slow breathing.

When the patient has been thoroughly instructed in self correction and in the exercises for muscle building, general gymnastics for systematic motor training, may be given effectively in groups of fifteen or twenty pupils. For such exercises the "days order" of the Swedish Educational Gymnastics is preferred.

These two systems of treatment by gymnastics have been selected as the most practicable of the many that have been devised. It may be stated that any treatment that makes the spine more flexible, that overcomes faulty attitudes and that strengthens the muscles, must be of benefit to the patient, the degree of benefit corresponding to the persistence and energy of the pupil and the instructor, rather than to any particular theory on which such treatment is based.

The Removal of Superincumbent Weight.—The removal of superincumbent weight by the assumption of the reclining posture whenever the patient is fatigued, is an important adjunct in the treatment of a certain class of cases.

Self Suspension.—Self suspension, by means of the halter and pulley is of service in overcoming secondary contractions of the tissues, and thus it aids in the correction of deformity. It is often efficacious also in relieving the discomfort that is sometimes a troublesome symptom when the distortion is extreme. While the patient is suspended, forcible manual correction of the deformity can be applied to advantage.

Suspension from the horizontal bar acts in a similar manner, although it is less effective than when the traction is made upon the entire spine.

In this form of suspension, the bar should be oblique in direction, the high side for the low shoulder. Thus a passive "keynote" is induced while the patient is suspended. Exercises in this position, for example, flexion and extension of the thighs, swaying the trunk from side to side, "chinning" the bar and the like, are useful.

The Use of Braces or Other Supports.—In the treatment of the ordinary type of lateral curvature, when there is an opportunity for proper gymnastic training, support is not indicated. There are, however, exceptional cases in which the deformity habit is so persistent, and

FIG. 130.

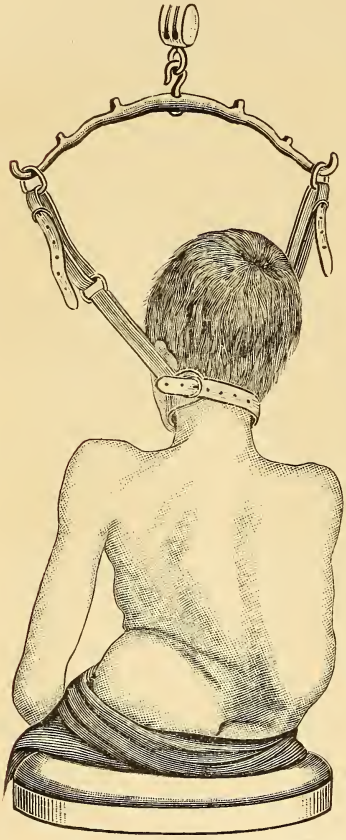
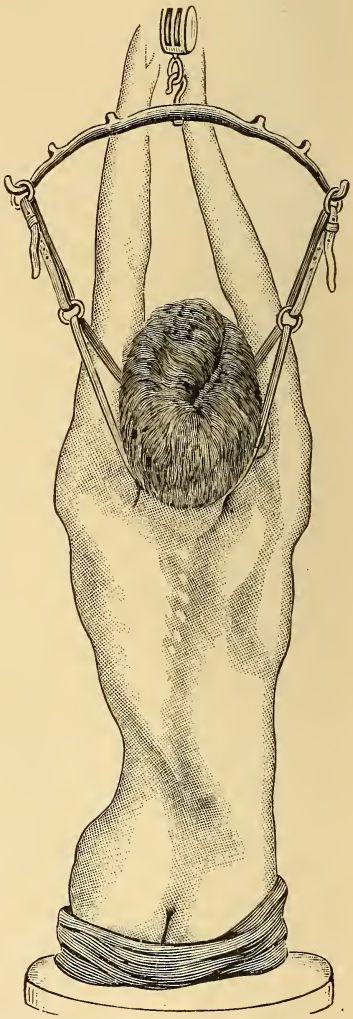


FIG. 131.



Self suspension illustrating the effect of traction in lessening deformity. (GIBNEY.)

in which the voluntary efforts of the patient to assume a better attitude are so ineffective, that support may be employed for a time with advantage.

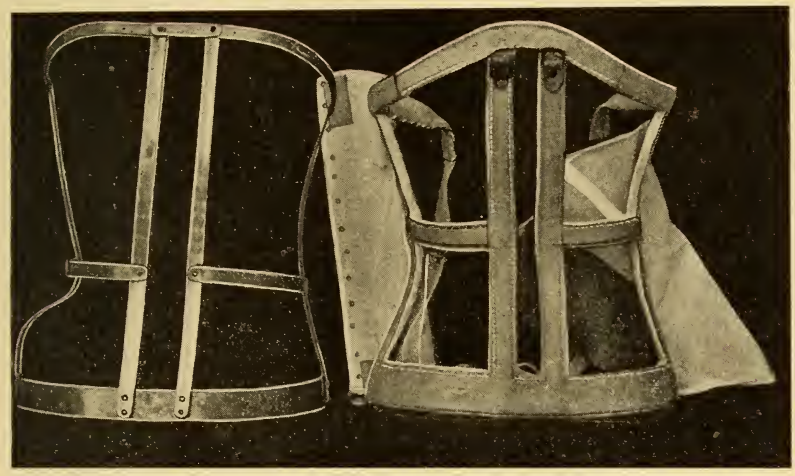
The best support is a plaster corset applied while the patient is sus-

pended. This may be removed at night and when the exercises are performed. Even while the corset is worn, the patient should endeavor to improve upon the attitude which it enforces, by assuming the key-note position and by flexing and extending the trunk on the hips.

When the deformity is dependent upon irremediable injury or disease, for example, anterior poliomyelitis or empyema, some form of brace may be employed to prevent excessive lateral deviation of the trunk; and in cases of fixed deformity in older subjects, especially if the patient is obliged to follow a fatiguing occupation, a support may be indicated, because of symptoms of discomfort or pain.

Support is employed primarily with the aim of preventing an increase of deformity and to relieve symptoms incidental to the deformity. It may, in some degree, also serve as a corrective appliance. If it holds the spine in the extended position or induces lordosis, it may, by reliev-

FIG. 132.



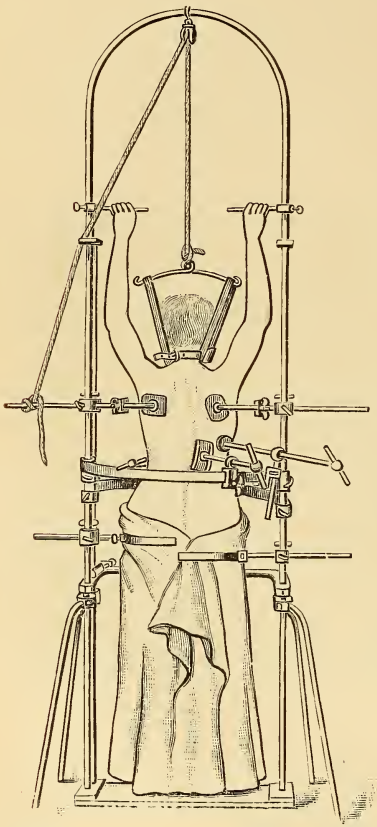
The Knight spinal brace.

ing the bodies of the vertebræ in part from the deforming influence of superincumbent weight, allow for slight untwisting of the rotation and a corresponding transformation of the distorted parts. On this principle a light steel brace after the Taylor model may be as effective as any of the more complicated appliances, as was suggested many years ago by Judson. Corsets of other material than plaster, for example, of paper, or of aluminium, as suggested by Phelps, may be employed when the deformity is fixed and when no change in the position or size of the trunk is to be expected. The Knight brace, when carefully adjusted, appears to meet the requirements fairly well, and when less support is needed, an ordinary corset strengthened by light steels may be sufficient.

Forcible Correction of Deformity.—In the treatment by gymnastic

exercises the patients are supposed to overcome by voluntary effort, as far as is possible, the secondary accommodative contractions of the soft parts that prevent the correction of the deformity. But in many instances the voluntary correction of deformity may be supplemented with advantage by the employment of force. For example, the patient may use the weight of the body as a means of correction by forcibly flexing the trunk over a padded bar (Fig. 138) and a variety of similar postures, either active or passive, with or without suspension may be utilized with the same object. Corrective force applied by the hands, the patient's trunk being flexed and rotated in the directions opposed to the deformities, although the most effective method, is the most fatiguing, and machines have been constructed with the aim of applying the force in similar manner. This is illustrated by the appliance of Hoffa, which has been modified by Schede and others. In this machine the patient is suspended, the hips are fixed and the pressure screws are applied upon the convexities of the double curve, with the aim of untwisting the spine. The correction is maintained for fifteen minutes or longer, and it is then followed by the regular exercises of the day. (Fig. 133.)

Fig. 133.



Forcible correction by means of the modified Hoffa appliance. (Bradford and Brackett.)

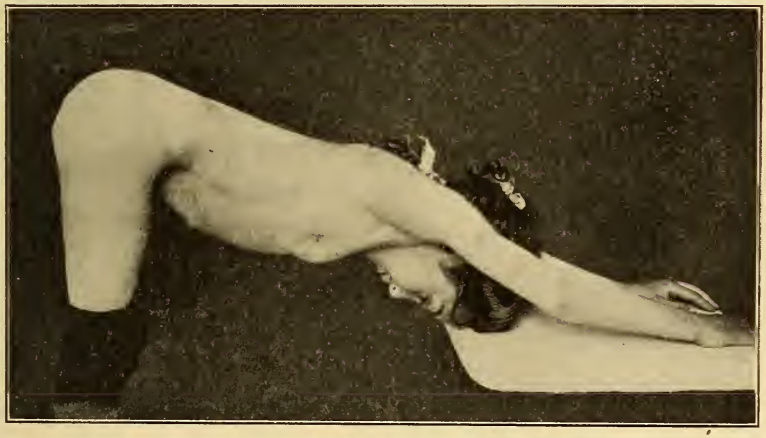
The Forcible Correction of Deformity Combined with Fixation.— Forcible correction and fixation is the treatment of selection for resistant lateral curvature in early childhood, because one cannot command the coöperation of the patient in maintaining the proper attitude, and because the rapid growth at this age, which favors the increase of the deformity is equally favorable to its cure if the static conditions can be changed.

For example, one treats the severe rhachitic kyphosis of infancy by fixation in the horizontal position, and by daily manual correction of the deformity. And in the treatment of older children, in whom posterior or lateral deformity is fixed, one is justified in using the same method for its relief and cure that would be employed in the treatment of Pott's disease. In this class the plaster of Paris jacket, applied

while the trunk is held in the best possible position, is the treatment of selection, a treatment that should be continued until the deformity is cured or until further rectification by this means is found to be impossible.

The most convenient method of applying the jacket is by means of the ordinary suspension apparatus. The back having been carefully padded at the points of pressure, the patient is suspended and while traction and manual corrective force are exerted the plaster bandages are applied. In this correction two points are of especial importance, to attain as much extension or over-correction as possible and to sway the entire body in the direction opposite to the habitual inclination. By over-extension one removes the weight in part from the vertebral bodies that are primarily deformed, and by lateral correction one endeavors to change the relation of the weight to the distorted part. This improved position must be carefully maintained by the hands

FIG. 134.



Congenital scoliosis. After treatment for three years by forcible correction and fixation by plaster jackets. Showing the disappearance of the rotation.

until the plaster bandages have become firm. The jackets may be changed at intervals of a month or more and at each application one attempts to improve upon the former position.

The jacket is used in preference to the corset because it holds the spine more perfectly. It is of course a disadvantage to employ such restraint, but as has been stated the prognosis in fixed rotary lateral curvature in a young child is, as regards ultimate deformity, extremely unfavorable, and one is justified therefore in sacrificing muscular activity in order that the original deformity of the bones may be remedied. As an illustration of persistence in this method of treatment it may be stated that it was continued by me for nearly three years in one case of extreme scoliosis of congenital origin with most gratifying success. (Fig. 134.)

The jackets may be applied also in the horizontal position, traction being exerted upon the arms and legs, combined with manual pressure

on the trunk, somewhat after the manner of the Calot method of correction of the deformity of Pott's disease.

When the deformity has been overcome, or when the continuation of the treatment seems undesirable, the jacket may be replaced by a corset, which may be removed for daily massage and for exercises. This may be finally discarded when the muscular strength has been regained.

As has been stated, forcible correction and fixation is essentially a treatment of deformity in early childhood. But in certain instances, when, for example, the deformity is extreme or is increasing rapidly, it may be employed in adolescence. In the treatment of this class of cases the plaster jacket is usually applied while the patient is fixed in the best possible position by means of some form of pressure apparatus, as is illustrated in Fig. 133.

Forcible correction of deformity under anæsthesia has little to recommend it, since whatever deformity can be corrected with anæsthesia can be corrected without it.

The Volkmann Seat.—In cases of primary lumbar curvature, or when the secondary curve of this region is pronounced, the attitude may be improved and the deformity may be corrected in part by seating the patient on an inclined plane, the high side beneath the low hip, thus lessening the convexity of the curve.

The High Shoe.—The same object may be attained in the erect posture by the use of a higher heel, or heel and sole. The elevation may be from a half inch to an inch and a-quarter, the amount being regulated by its effect upon the contour of the trunk.

Posture and Support During Recumbency.—The attitudes habitually assumed during recumbency should be investigated. The bed should be provided with a hard mattress and a low pillow, and the patient should be encouraged to lie upon the side in an attitude which opposes the deformity, or upon the back. The rectification induced by such an attitude may be still further increased by the use of a hard pillow beneath the convexity or beneath the back, and in certain instances the Barwell sling may be employed with advantage.

General Treatment.—The importance of improving the general condition of the patient by regulation of the diet, by cold baths and by active exercise in the open air is self-evident. The strain upon the back should be lessened by providing proper seats and by limiting the time passed in passive attitudes, and by lessening, as far as is possible, the restraint of the clothing. These precautions are of almost equal importance with the active treatment.

The Duration of Treatment.—The duration of treatment depends of course upon the character of the deformity and upon its causes. In the ordinary type of adolescent scoliosis, the duration of active treatment is usually from three to six months. In this time the muscles may be so strengthened and the necessity for constant attention to the attitudes may be so impressed upon the patient, that the simple exercises which may be performed at home, may be sufficient. It is well, however, if possible, to keep the patient under supervision during the period of growth.

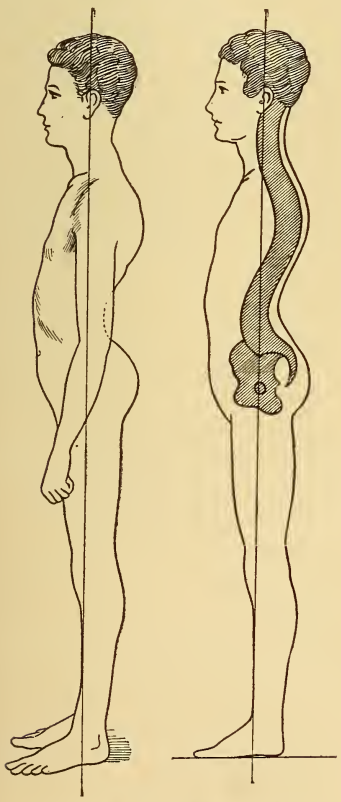
CHAPTER IV.

DEFORMITIES OF THE SPINE.—*Continued.* DEFORMITIES OF THE CHEST. THE FUNCTIONAL PATHOGENESIS OF DEFORMITY.

Variations in the Contour of the Spine.

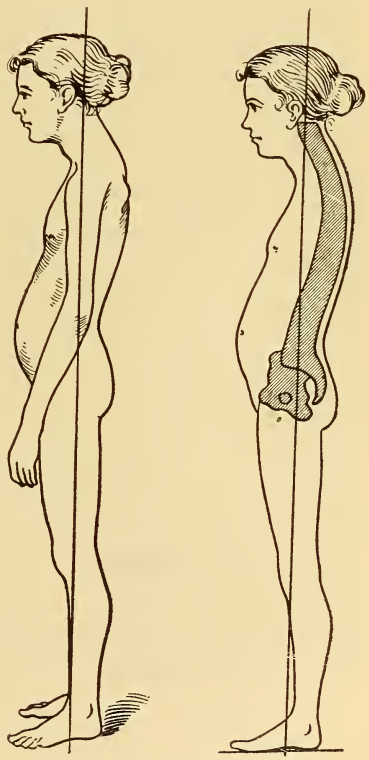
One recognizes a certain contour of the spine as normal, but there are variations from this type which, within certain limits, can hardly be classed as abnormal. Two of these have been mentioned, the round

Fig. 135.



The hollow round back. (Hoffa.)

Fig. 136.



The round back. (Hoffa.)

back (Fig. 136) in which there is a general forward droop most marked at the shoulders; and the **hollow round back** (Fig. 135) in

which the dorsal kyphosis and the lumbar lordosis are somewhat exaggerated. A third type is **the flat back** (Fig. 71), in which there is neither a lumbar lordosis nor a dorsal kyphosis. In the marked cases there is an actual prominence in the lumbar region, while the scapulæ project backward from the flattened dorsal spine. This type of back is probably the result, in many instances, of a rhachitic kyphosis which was most prominent in the lumbar region. The flat back and the round back predisposed to lateral curvature.

Antero-Posterior Deformities of the Spine.

Kyphosis.—As has been stated in the chapter on Pott's disease, the spine is practically straight at birth. If during the early weeks of life an infant be placed in the sitting posture the head falls forward and the spine bends into a long posterior curve, the posture of weakness. The normal anterior convexity of the cervical section is established when the gain in muscular power enables the infant to hold the head erect, and that of the lumbar region when the pelvis is tilted downward by the extension of the thighs in the erect posture.

Fig. 137.

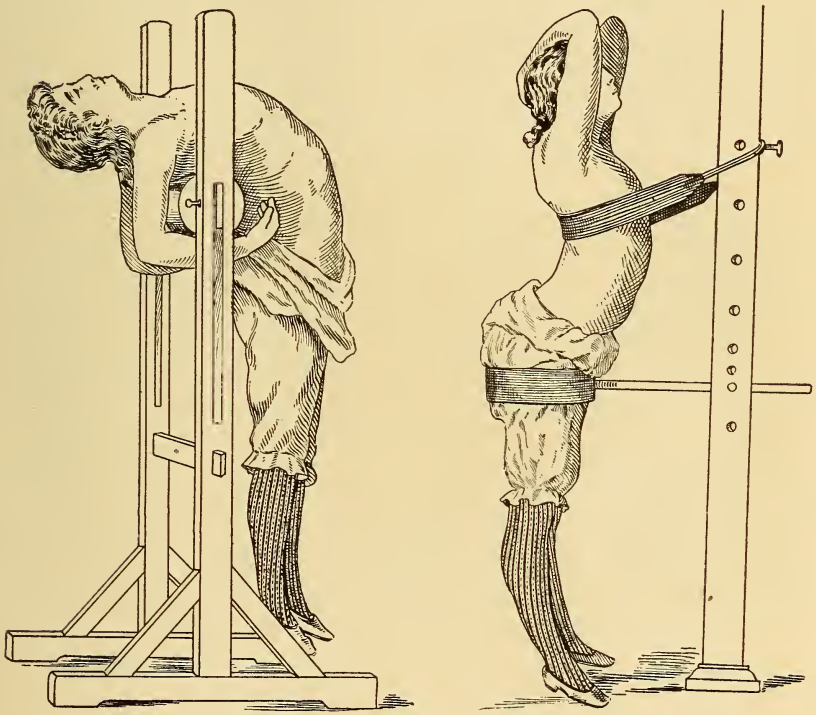
Marked posterior curvature of the spine apparently induced by weakness incidental to illness.

In the erect posture the constant tendency of the weight of the head and of the thoracic and abdominal organs is to draw the spine forward and to reëstablish the original posterior curve. This tendency is resisted by the action of the posterior muscles of the trunk. Whenever, therefore, the muscular power is lessened or the body is over-burdened or whenever the spine is weakened by disease the tendency toward the original curve of weakness, becomes apparent. (Fig. 137.) Thus the causes of an abnormal increase in the posterior curvature of the spine are very numerous. It is, as has been stated, the characteristic attitude of weakness as is illustrated in infancy and in old age. It is one of the common occupation deformities of adult

life; it is a common postural deformity of childhood and adolescence. It may be induced by a variety of diseases that lessen the resistance of the spine or that interfere with its function. For example, by rhachitis, spondylitis deformans, osteitis deformans, Pott's disease and affections of a similar nature.

The kyphosis of rhachitis is most marked in the lower region, that of spondylitis deformans may involve the entire spine, while the simple postural curvature is most marked in the upper dorsal region. In a number of the postural deformities the increase in the dorsal kyphosis

FIG. 138. FIG. 139.



Exercises for the correction of posterior curvatures of the spine. (HOFFA.)

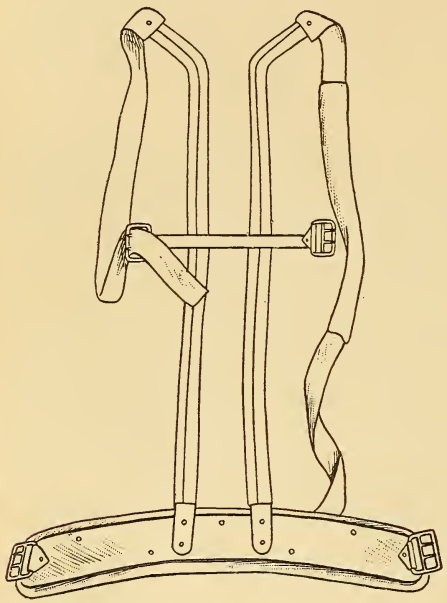
is balanced by an increased lordosis and in this form there is simply an exaggeration of the normal curves of the spine, the "hollow round" back. In other instances there is a general forward droop of the trunk in which the lumbar lordosis may be lessened; this form is more common in childhood, the "round" back.

The forms of kyphosis that are the direct result of disease have been described elsewhere. *Postural kyphosis*, "round shoulders," is one of the common deformities, and in childhood its etiology is similar to that of lateral curvature, of which it may be a predisposing cause. Round shoulders and the accompanying flat chest may be induced also by ob-

structions in the respiratory passages, such as enlarged tonsils, adenoids and the like or by bronchitis or heart disease. Another predisposing cause is clothing that prevents the full expansion of the chest and the extension of the arms, and even the weight of clothing suspended from the shoulders may be a factor in the etiology. These possible contributing causes should be investigated in all cases of this type.

Treatment.—The treatment is similar to that of lateral curvature. The assumption of the military attitude with the head erect, the chin depressed, the shoulders thrown back, the chest expanded and the abdomen retracted, should be encouraged. And those exercises that expand the chest and that strengthen the muscles of the upper part of the spine, are especially important. (Such exercises are illustrated by Figs. 95, 96, 103, 104, 109, 110, 119, 125, 127, 129, 138 and 139.) If the range of vertical extension of the arms is limited, this restriction must be overcome before the deformity of the spine can be permanently improved. In well-marked cases the patient should be encouraged to read or study in the prone posture in this attitude in which the trunk must be supported upon the elbows and the head held backward, there is necessarily an involuntary correction of the deformity. In certain instances, a light spinal brace may be employed during the hours when the passive attitude must be assumed, but as a rule artificial support should be avoided. (Fig. 140.) Shoulder braces, so-called, are useless. Clothing should not restrict the movements of the arms or trunk, and as little weight as possible should be suspended from the shoulders.

FIG. 140.



Tempered steel uprights for round shoulders. (BRADFORD AND LOVETT.)

Lordosis.—Lordosis, or an abnormal hollowness of the back, is far less common than kyphosis. It is not a simple postural deformity, but it is usually secondary to disease or deformity either of the spine or of the adjoining members. For example, lordosis may be induced by flexion contraction of the thighs; it is a symptom of congenital displacement of the hips; it is sometimes a result of certain forms of nervous disease, in which, because of muscular weakness, the body is swayed backward to retain the balance, as in pseudo-hypertrophic paralysis. Lordosis in the lumbar region may be a compensation for a

kyphosis in the upper segment. It is caused directly by spondylolisthesis. It may be a congenital deformity and it is said to be a peculiarity of contortionists.

Treatment.—As lordosis is usually a secondary deformity its treatment would be included in the treatment of its causes. In some instances the discomfort which is usually present when the deformity is well marked may be relieved by a proper corset sufficiently strong to support the back.

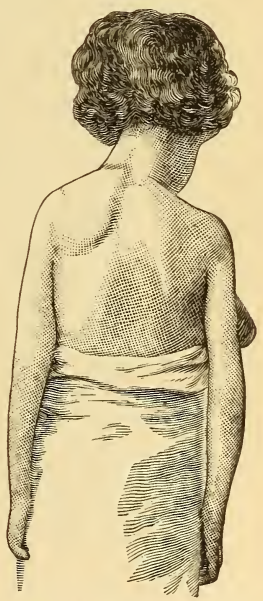
Congenital Elevation of the Scapula.

Synonym.—Sprengel's Deformity.

Sprengel's deformity is a congenital elevation of the scapula above the level of its fellow, an elevation accompanied in most instances by rotation, so that its lower angle is brought nearer to the spine. The cervical muscles passing to the scapula are shortened and changed in direction. Thus its mobility is lessened and consequently the range of vertical extension of the arm is restricted.

In many instances the deformity is accompanied by a lateral curvature of the spine, the convexity being usually toward the deformed side. In a case treated at the Hospital for Ruptured and Crippled, the elevation of the scapula was accompanied by marked torticollis and asymmetry of the face, and in two cases recently reported by H. A. Wilson[1] the posterior border of the scapula was fixed to an elongated cervical spinous process.

Fig. 141.



Congenital elevation of the left scapula. (Wilson.)

The first adequate account of the deformity was that of Sprengel,[2] who described four cases in children from one to seven years of age. In 1898 Pitsch[3] described seventeen other cases collected from literature, and since then a large number of cases have been reported by other observers. In four cases, three reported by Kölliker[4] and one by Hoffa, the projecting upper border of the scapula, reaching nearly to the clavicle, was mistaken for an exostosis.

Etiology.—The etiology is doubtful, but the deformity appears to be the result of a constrained position of the fœtus in utero. In two of Sprengel's cases seen soon after birth, the arm appeared to have been fixed behind the back of the child.

Congenital elevation of the scapula may be simulated by the distortion and muscular atrophy resulting from birth palsy, or even by cer-

[1] Annals of Surgery, April, 1900.
[2] Archiv für klin. Chir., Bd. 42, 1891.
[3] Zeit. für Orth. Chir., Bd. 6, H. 1.
[4] Centb. für Chir., 1895.

tain cases of rotary lateral curvature in which the scapula is elevated and prominent.

Treatment.—If the case is seen in infancy and if the contraction of the vertebro-scapula muscles is extreme, the shortened tissues may be divided by open incision as in torticollis, and if, as in Wilson's cases, the scapula is joined to the spine the elongated spinous process should be removed. In older subjects no treatment, other than that for the lateral curvature, is as a rule indicated.

The Absence of Vertebræ.

Absence of vertebræ is usually associated with rhachischisis. Three cases however have come under my observation in which there was absence of vertebræ without other malformation. In two of the cases the deficiency was in the cervical region, in one in the lumbar. The noticeable shortness of the affected section of the spine was the only symptom.

Deformities of the Chest.

The Flat Chest.—The so-called flat chest is an accompaniment of the round back. (Fig. 136.) In most instances the chest is not actually flattened in the sense that its antero-posterior diameter is diminished. It appears flatter because the shoulders and scapulæ are displaced forward.

Woods Hutchinson has called attention to the fact that the so-called flat chest is usually a round chest, in the sense that it is actually deeper than the normal, a persistence of the fœtal type. He suggests that such persistence may be one of the causes of so-called round shoulders, the round chest affording no adequate support for the scapulæ.

Hutchinson[1] has presented an index showing the relative depth of the chest at different ages, illustrating the progress from the keel chest of the lower orders to the bellows shape of the adult human form. This index is found by dividing the antero-posterior diameter at the nipples by the transverse diameter at the same level, hence the lower the index, the longer and flatter, more bellows-like the chest.

Fœtal index	103
Infantile "	87
Child "	90
Adult "	72

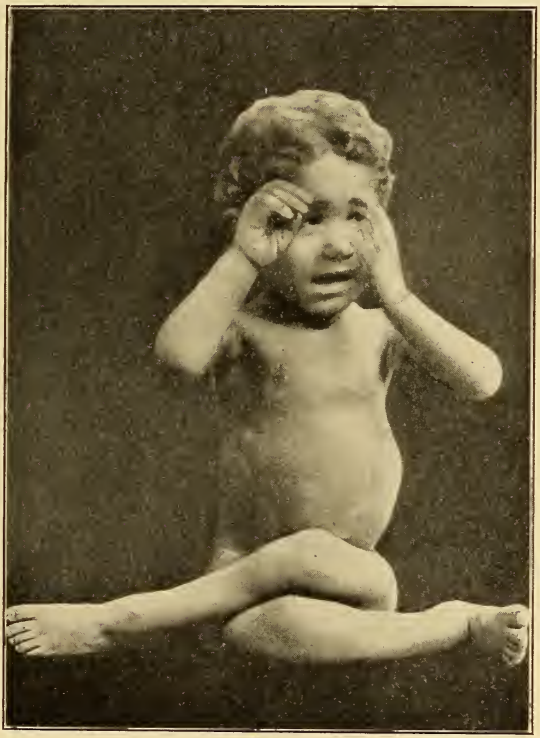
Treatment.—The treatment of the so-called flat chest is similar to that of the round shoulders with which it is often combined, that is by exercises conducted with the special object of improving the strength of the muscles of the back and increasing the expansion of the upper part of the chest. The importance of correcting the deformity, which interferes with the proper expansion of the lungs and thus predisposes to disease, should be evident.

Pigeon Chest. Synonym.—Pectus Carinatum.

[1] Journal American Medical Association, Sept. 11, 1897.

The pigeon, or keel-shaped, chest resembles the quadrupedal type in that the antero-posterior is increased at the expense of the lateral diameter. The sternum is thrust forward and downward like the keel of a boat, the lateral compression being most marked at the junction of the ribs and the cartilages. This deformity is almost always acquired (Fig. 142); it is usually an effect of rhachitis and it is described under that heading. It may be induced by obstruction of respiration caused by enlarged tonsils and the like, if this is present at an early age. It may be a secondary effect of the sinking forward and downward of the

FIG. 142.



General rhachitic distortions and pigeon chest.

upper half of the trunk as in Pott's disease of the middle of the spine.

Treatment.—The treatment would be included in the treatment of the affection of which it is the result. The tendency in rhachitic pigeon chest is toward spontaneous cure; it is rarely seen in adult life.

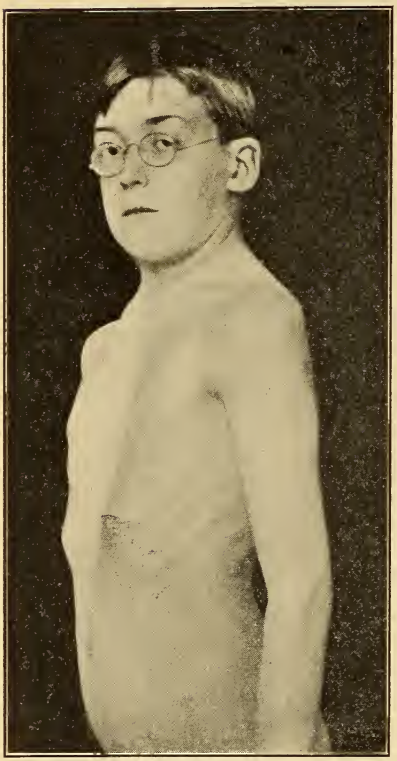
The Funnel Chest. Synonym.—Pectus Excavatum.

This deformity when well marked is the direct opposite of the keel (Fig. 143) chest. The sternum is depressed and the lateral diameter of the thorax is correspondingly increased. The milder types of the affection in which there are one or more depressions or hollows in the

sternum are common. The extreme form, in which the entire sternum is depressed, is rare. It is practically always a congenital deformity, and it is not susceptible to direct treatment.

Minor Deformities of the Chest.—As has been stated, distortions of the chest secondary to deformity of the spine are often discovered before the original cause is suspected. And the importance of the various minor irregularities of the chest or in the direction of the ribs when once discovered is often exaggerated. They are usually the result of preceding rhachitis and no especial treatment is required.

Fig. 143.



Pectus excavatum. This patient has ocular torticollis also.

Absence of Ribs.—Absence or defective formation of ribs is uncommon. In such cases there is usually defective formation of the corresponding muscles, and lateral curvature of the spine is a common accompaniment.

Defective Formation of the Pectoral Muscles.—Several instances in which one or both of the pectoral muscles were defective or absent, have been observed at the Hospital for Ruptured and Crippled. The malformation in these cases caused no direct symptoms.

Absence or Defect of the Clavicle.—A number of cases of defective formation of the clavicle on one or both sides are recorded. In most instances a portion of the sternal extremity is present. The defect appears to cause but slight inconvenience.[1]

Acquired Luxation or Subluxation of the Clavicle.

Partial displacement of the sternal end of the clavicle is not particularly uncommon. In some instances it is caused by injury; in others no cause can be assigned. Most often there appears to be a laxity of the capsular ligament that allows a displacement during certain movements of the arm. The displacement is readily reduced, but the weakness and insecurity may cause discomfort and disability.

Treatment.—In some instances the displacement may be prevented by the pressure of a pad and truss spring, attached behind to the corset

[1] Schornstein and Carpenter, Lancet, Jan. 7, 1899.

or braces and passing over the shoulder close to the neck. Such an appliance is especially useful if the displacement occurs at certain times only, as in dressing the hair, playing on the violin, etc. Cures are reported as the result of the injection of alcohol into the joint from time to time, and Wolff[1] has operated with success as follows: The joint is opened by a straight incision. A fragment of bone is detached from the clavicle above and a similar one from the sternum; these, still adherent to the periosteum, are overlapped in front of the joint and the capsule is then sutured.

Asymmetrical Development.

In normal individuals there is often a slight difference between the two halves of the body and as is well known, inequality in the length of the legs is not at all uncommon. Inequality of the two halves of

FIG. 144.

Hypertrophy of the right forearm and hand, due to congenital nævus.

the body may be congenital and it may be evident at birth, but usually it does not attract attention until adolescence. In many instances this inequality is a slight atrophy, the result of a cerebral hemiplegia of early childhood. In other instances the inequality may be due to congenital hypertrophy that may affect the entire limb. In such cases the enlarge-

[1] Cent. für Chir., Nov. 30, 1893.

ment may be due to an abnormal amount of normal tissue, but in most instances the hypertrophy, which becomes more marked with the growth of the child, is caused by an abnormal blood supply, a form of congenital nævus. (Fig. 144.)

TABLES OF WEIGHT, HEIGHT AND CIRCUMFERENCE OF THE CHEST.—BOAS.

		Pounds.	Kilos.	Height.		Chest.	
				In.	Cm.	In.	Cm.
Birth	Male.	7.55	3.43	20.6	52.5	13.4	34.2
	Female.	7.16	3.26	20.5	52.2	13.0	33.2
6 months	Male.	16.0	7.26	25.4	64.8	16.5	42.0
	Female.	15.5	7.03	25.0	64.6	16.1	41.0
1 year	Male.	20.5	9.29	29.0	73.8	18.0	45.9
	Female.	19.8	8.84	28.7	73.2	17.4	44.4
18 months	Male.	22.8	10.35	30.0	76.3	18.5	47.1
	Female.	22.0	9.98	29.7	75.6	18.0	45.9
2 years	Male.	26.5	12.02	32.5	82.8	19.0	48.4
	Female.	25.5	11.56	32.5	82.8	18.5	47.0
3 years	Male.	31.2	14.14	35.0	89.1	20.1	51.1
	Female.	30.0	13.60	35.0	89.1	19.8	50.5
4 years	Male.	35.0	15.87	38.0	96.7	20.7	52.8
	Female.	34.0	15.41	38.0	96.7	20.5	52.2
5 years	Male.	41.2	18.71	41.7	106.8	21.5	54.8
	Female.	39.8	18.06	41.4	105.3	21.0	53.5
6 years	Male.	45.1	20.48	44.1	112.0	23.2	59.1
	Female.	43.8	19.87	43.6	110.9	22.8	58.3
7 years	Male.	49.5	22.44	46.2	117.4	23.7	60.6
	Female.	48.0	21.78	45.9	116.7	23.3	59.5
8 years	Male.	54.5	24.70	48.2	122.3	24.4	62.2
	Female.	52.9	24.01	48.0	122.1	23.8	60.8
9 years	Male.	60.0	26.58	50.1	127.2	25.1	63.9
	Female.	57.5	26.10	49.6	126.0	24.5	62.5
10 years	Male.	66.6	30.22	52.2	132.6	25.8	65.6
	Female.	64.1	29.07	51.8	131.5	24.7	63.0
11 years	Male.	72.4	32.83	54.0	137.2	26.4	67.2
	Female.	70.3	31.87	53.8	136.6	25.8	65.8
12 years	Male.	79.8	36.21	55.8	141.7	27.0	68.8
	Female.	81.4	36.90	57.1	145.2	26.8	68.3
13 years	Male.	88.3	40.04	58.2	147.7	27.7	70.6
	Female.	91.2	41.36	58.7	149.2	28.0	71.3
14 years	Male.	99.3	45.03	61.0	155.1	28.8	73.3
	Female.	100.3	45.50	60.3	153.2	29.2	74.1
15 years	Male.	110.08	50.26	63.0	159.9	30.0	76.6
	Female.	108.04	49.17	61.4	155.9	30.3	76.8

THE FUNCTIONAL PATHOGENESIS OF DEFORMITY.

Wollf's Law.

Mention has been made, and will be made again from time to time, of the adaptation of members or parts to abnormal conditions, and of the transformation of deformed parts to the normal when the improper re-

lations of weight and strain have been removed. This theory or law of functional adaptation has been established by Professor Julius Wollf, of Berlin, who has shown its application to the bones, the most unyielding structures of the body. He first called attention to the fact that the shape of a bone is the effect of function. It is the effect of function in that if the work required of it had been different, its shape would have been different. This function has shaped not only the external contour but the internal structure as well. If a bone is broken, for example the neck of the femur, and deformity results, the internal architecture is no longer suitable for the new conditions of weight and strain, and immediately a rearrangement begins, which finally transforms the internal structure, not only in the neighborhood of the injury, but in the extremity of the bone also, to adapt the deformed part as well as may be to the work that is now demanded of it.

The normal bone is braced most thoroughly, and is most resistant at the points where most work is required of it. If the weight and strain are for any reason transferred to another part, its structure becomes hypertrophied there, and correspondingly weakened at the point from which the strain has been removed. With this change in the internal structure a change in the external contour keeps pace.

For the further exposition of this theory I quote from Freiberg's [1] review and abstract of Wollf's [2] final article.

"In showing that improper static demands made upon an extremity resulted in the formation of new masses of bone upon the surface of the bone of this extremity, or that they produced the disappearance (atrophy) of bone masses according to the nature and degree of these disturbances in static requirements, it has at once been shown in what manner deformities have their origin. For these transformations on the surface of bones are nothing other than 'deformities' in the wider or narrower sense of the term.

"Taking genu valgum or habitual scoliosis as example, the development of a deformity in the narrow sense is thus explained. In the beginning of either of these conditions the shape of the bones is perfectly normal. As the result of excessive fatigue in their too weak muscles the patients are frequently assuming a faulty position of limb or body; they seek to control excessive excursions of their joints by the interference of the articular structures themselves, instead of by muscular activity. The result is a continual alteration in the static requirements made upon the bones and the internal architecture; internal and external configuration of the bones accommodate themselves to the new conditions. Since, according to this reasoning, deformities are nothing else than the result of these transformations which the external form of bones or joints undergo in accommodating itself to faulty demands made upon them, it must be self-evident that these de-

[1] Annals of Surgery, July, 1897.

[2] Jul. Wollf, Die Lehre von der functionellen Pathogenese der Deformitäten Archiv für klinische Chirurgie, Bd. LIII., H. 4.

formities are to be considered pathological only in the sense that hypertrophy of the cardiac muscle in valvular insufficiency is pathological. That which is really pathological is only the altered static requirements, the abnormal mechanical function. Far from being pathological the deformity is the only suitable or even possible form by means of which bone or joint can withstand the altered forces bearing upon it; it is nature's way of securing the greatest possible service and strength, under the new conditions, with the use of the least possible amount of material.

"The pathogenesis of deformities is therefore functional. Genu valgum, for instance, represents only the functional accommodation of femur, tibia, and knee-joint to the improper static demands made by the outward deviation of the leg. Just so are the shapes of the bones in club-foot the expressions of similar functional accommodation to an inward rotation of the foot, or even, sometimes, an inward turning of the whole lower extremity. The faulty position of an extremity under these circumstances is to be regarded rather as a cause of the deformity than as an effect. This faulty position must always occupy a place intermediate between the remote causes of deformity (hereditary predisposition, habit, muscular weakness, external conditions causing pressure or narrowing space for growth) and the anatomical results which these various remote causes bring about.

"When the altered demands upon an extremity do not occur spontaneously, as in the above instances, but, on the other hand, result from a primary disturbance in the shape of the bones, due to trauma or bone-disease with consequent softening or destruction of tissue, there is added to this a secondary change in the external configuration of the bones, and there is thus caused a 'deformity in the broad sense of the word.' The difference between the two varieties of deformity, therefore, lies only in the addition of a second etiological factor (the trauma, etc.) to the deformity in the broad sense. Both varieties have it in common that the shape of the bones and joints of the deformed part represents nothing else than the expression of a functional accommodation to the faulty static demands made upon it."

"As a second example by means of which to explain the correctness of the doctrine of functional pathogenesis the author has selected scoliosis. In the first chapter the author showed in detail that the altered conditions in the length and height of the transverse processes of scoliotic vertebræ as well as corresponding conditions in the ribs of the scoliotic thorax are so evident as not possibly to escape notice, and that they can be explained in no other way than as functional accommodation to the circumstances of space, changed and brought about by the continual, faulty, and cramped position of the thorax; this is as true of the convex as of the concave side of the vertebral column, to which the transverse processes and ribs in question belong. It must be manifest that changed relations of one part of the skeleton to any other part of the skeleton (as far as space conditions are concerned) necessarily bring about changes in the mechanical demands made upon

this part, and therefore changes in the directions and values of the pressure, tension, and shearing strains of each and every point in this part of the skeleton. The conclusion thus drawn, that accommodation to space means the same as accommodation to function, is of greatest importance to the *general* doctrine of functional accommodation.

"The origin of the wedge-shape of the scoliotic vertebra now comes under discussion. It is assumed by the majority of writers that an abnormal softness of the bones is present in scoliosis by means of which a faulty position can model the bodies of the vertebræ as it does in the case of rachitic disease of bone, or as is really the case with the intervertebral discs in cases of 'habitual scoliosis.' While unsupported by any pathologic-anatomical investigations, it is allowed possible, or even probable, that such softness of the bones plays a *rôle* in many cases of scoliosis. It is certain, however, that this is by no means always the case; as evidenced by the development of scoliosis after empyema in adults, and the great exaggeration in adult life of very slight scolioses originating during youth. It is concluded, on the contrary, that the vertebra may acquire its scoliotic wedge shape entirely independent of the pressure of the superincumbent weight. Furthermore, in the absence of any abnormal softness of the bones, the body of a vertebra may lose height on the concave side, and gain the same on the convex side through the 'tropic stimulus of function' purely; being simply an accommodation to the diminished space on the concave side and increased room at the convexity and the change of mechanical conditions consequent thereupon.

"This simple and natural conception of the circumstances concerning the scoliotic wedge must obtain credence, especially since the old view, corresponding to the 'pressure theory,' has been long ago disproved by Hoffa and Nicoladoni—namely, that the concave side of the wedge is the seat of atrophy, and that this atrophy accounts for the loss in height of the vertebral body on this side."

The importance of Wollf's theory which shows how deformity may be acquired and how it may be avoided, is very evident. It is of equal importance in indicating the principles of treatment. For example, from the anatomical description of a club foot the distortion might appear to be irremediable, but on this theory one feels assured that if the foot can be fixed for a sufficient time in the over-corrected position, the influence of the new static conditions will immediately induce a transformation, not only in soft parts but in the bones as well, that will finally effect a complete and absolute cure. So also the correction of a distorted bone by operative means is at best but imperfect; if however the static conditions have been changed, nature will in time reconstruct the entire bone so perfectly that, in a few years, practically no trace of the former distortion, either in contour or internal structure, will be evident. Scoliosis might be cured as perfectly as the club foot or the bow leg, were it possible to restore as easily the normal conditions of weight and strain.

CHAPTER V.

TUBERCULOUS DISEASE OF THE BONES AND JOINTS.

Etiology.—Three factors are recognized in the etiology of tuberculous disease: the infectious element (the tubercle bacillus), the general predisposition of the patient, and the local condition that favors the reception and the growth of the bacilli.

Predisposition.—The predisposition, both general and local, is spoken of as lessened vital resistance. A general predisposition to disease may be inherited, or it may be acquired. Thus a history of tuberculosis in the immediate family of the patient is supposed to imply a lessened resistance to this form of disease. In a certain proportion, perhaps 25 per cent. of the cases, this inherited predisposition is very direct and positive, but in the larger number the family history is as indefinite as in a similar class of patients under treatment for any other form of ailment. The acquired predisposition is of more direct importance since it would include the lowering of the vitality due to improper food and improper hygienic surroundings of every variety, together with the greater liability to depressing diseases and the more constant exposure to tuberculous infection that such conditions imply. Thus tuberculous disease of the bones, as well as of other parts, is more common among the poor of cities than among the more favored classes.

Mode of Infection.—The tubercle bacilli may be introduced to the body by inhalation and find their way to the bronchial glands, or by the mouth and set up disease in the mesenteric glands, or, after infection of the nasal passage or neighboring parts, secondary disease of the cervical lymphatics may appear in the so-called scrofulous glands of the neck.

Latent Tuberculosis.—It may be assumed that disease of the bronchial and mesenteric glands is not uncommon in individuals of apparently perfect health since it is often discovered at autopsies in those who have died from other causes. This form of glandular disease is called latent tuberculosis and it usually precedes a local outbreak in the bone or elsewhere. In many instances the disease may remain latent and finally disappear or it may persist and from time to time free bacilli or bits of infected tissue may escape into the blood current; by it they are deposited in other parts, where, under favoring conditions, local disease may be set up. Depression of the vitality from any cause may be supposed to favor the progress of the glandular disease which may lead to a dissemination of the infectious elements, and at the same time it may lessen the resistance of other tissues that may be exposed

to the infection. This accounts for the well-known influence of certain diseases such as measles and whooping-cough, not only in predisposing to local tuberculous disease, but in favoring its progress when it is already established. It is, however, possible that the bacilli that have found their way into the blood current, may set up primary disease of a bone or joint. In fact it is stated by König [1] that in 14 of 67 autopsies on subjects who had suffered from tuberculous disease of the bones and joints, no other foci were found in the body. And in other instances the source of infection may be preëxistent disease of the lungs or of other internal organs.

In 769 autopsies on children under twelve years of age, at the Hospital for Children, Great Ormond St., London, reported by G. F. Still,[2] 269 presented tuberculous lesions. Of these 269, 117 were less than two years of age.

The apparent channels of infection, as evidenced by the appearance of the glandular lesions, were as follows :

Respiratory.		
Lungs	105	
Probably lungs	33	
Ear	9	
Probably ear	6	
	153	—57 per cent.
Alimentary.		
Intestines	53	
Probably intestines	10	
	63	—23.4 per cent.
Other Cases.		
Bones or joints	5	
Fauces	2	
Uncertain	46	
	53	

Northrup and Bovaird [3] have made similar observations at the N. Y. Foundling Hospital.

Infection by respiratory tract	148
Infection by mesenteric lymph nodes	3
Indeterminate	48
	200

In sixteen instances the process was confined to the bronchial glands and in no instance were these glands found to be free from disease.

Local Predisposition.—The local conditions that favor the growth of the tubercle bacilli may be induced by injury. Slight injury sufficient to cause, for example, a hemorrhage into the substance of the

[1] Deutsch Chir., L. 28a, S. 157, 1900.
[2] British Med. Jour., August 19, 1899.
[3] Northrup, N. Y. Med. Jour., February 21, 1891. Bovaird, N. Y. Med. Jour., July 1, 1899.

cancellous tissue, induces a local congestion during the process of repair that provides the proper soil for the growth of the bacilli when they are deposited in its neighborhood. This has been proved experimentally by Krause and it is supported by clinical evidence. The great preponderance of disease in the lower over that of the upper extremities in childhood is supposed to be another argument in favor of the influence of injury in the causation of disease.

In 271 of 1,156 cases of tuberculosis of the bones and joints, treated at the Clinics at Göttingen and Breslau,[1] injury seemed to be a direct predisposing cause of the local disease, twenty-three per cent. A much higher percentage than this has been assigned by other writers, but the exact relation of traumatism to disease can only be conjectured.

The seat of the disease is almost always in the newly formed bone about an epiphyseal cartilage. This tissue is vulnerable; it is therefore more exposed to direct injury; it is subjected also to the strain of motion at the neighboring joint, and as the circulation is here more active the bacilli are more often deposited in this situation.

The vulnerability of growing bone accounts also for the relative frequency of bone disease in childhood, as compared with adult life. Injury not only causes a local predisposition to disease, but it favors its progress when it is once established.

Distribution of the Disease.—In 13,308 cases of tuberculous disease of the bones and joints treated at the Hospital for Ruptured and Crippled the distribution was, in order of frequency, as follows:

Vertebræ	5,662	42.5 per cent.
Hip Joint	4,048	30.5 "
Other Joints	3,598	27.0 "
	13,308	

In a total of 3,561 cases treated at the Hospital for Ruptured and Crippled and at the Vanderbilt Clinic, during the past five years, the distribution was as follows:

Vertebræ	1,432	40.2 per cent.
Hip Joint	1,123	31.5 "
Knee "	699	19.6 "
Ankle "	196	5.5 "
Elbow "	62	
Shoulder "	42	3.1 "
Wrist "	7	
	3,561	

Trunk	1,432	40.2 per cent.
Lower Extremities	2,018	56.6 "
Upper "	111	3.1 "

The correspondence between these two tables of statistics is striking and the number of cases is so large that the proportions may be accepted as approximately correct as applied to the distribution of the disease in childhood.

[1] Krause, Deutsch Chir., L. 28a, S. 161, 1900.

At the Boston Children's Hospital in a period of twenty-five years, 1869–1893, 3,820 cases were treated.[1] The distribution was as follows:

Vertebræ	1,964	51.4 per cent.
Hip	1,402	36.7 "
Ankle	300	7.8 "
Knee	104	2.7 "
Wrist	20	
Shoulder	15	1.3 "
Elbow	15	
	3,820	

Trunk	1,964	51.4 per cent.
Lower Extremities	1,806	47.2 "
Upper "	50	1.3 "

Side Affected.—Disease of the joints is slightly more common on the right than on the left side of the body. At the Hospital for Ruptured and Crippled the proportions in the cases treated during the past ten years, are as follows:

Hip—right	53 per cent.
Knee—right	55 "
Ankle—right	50 "
Shoulder—right	64 "
Elbow—right	60 "

It has been stated that one of the explanations of the great preponderance of the disease of the lower over the upper extremity, is the greater liability to injury. The same explanation has been advanced to account for the greater frequency of disease on the right side, which is more marked in the upper than in the lower extremity because the right arm is more liable to overwork as well as to injury.

Sex.—Tuberculous disease of the joints is somewhat more common among males than females.

Of 3,822 cases of Pott's disease treated at the Hospital for Ruptured and Crippled, 2,037 or 53 per cent. were in males.

Of 3,307 cases of disease of the hip joint treated at the same institution 1,731 or 52.3 per cent. were in males.

Of 1,218 cases of disease of the knee joint, combined statistics of Koenig and Gibney, 703 or 57.6 per cent. were in males.

Age.—In 5,461 cases of tuberculous disease treated at the Hospital for Ruptured and Crippled, about seven-eighths of the patients were less than fourteen years of age.

Less than 14 years of age	Vertebræ	87.7 per cent.
	Hip	88.2 "
	Other joints	71.7 "
Between 14 and 21 years of age	Vertebræ	7.7 per cent.
	Hip	9.2 "
	Other joints	10.7 "
More than 21 years of age	Vertebræ	4.5 per cent.
	Hip	2.5 "
	Other joints	17.5[2] "

[1] Report of the Boston Children's Hospital. [2] Knight, Orthopedia.

Of 1,259 cases of Pott's disease treated recently at the same institution, 1,075, 85 per cent. of the patients were in the first decade; 50 per cent. were three to five years of age inclusive at the inception of the disease.

In 1,000 cases of disease of the hip joint, the ages of the patients correspond closely to these, 87.2 per cent. were in the first decade and 45.2 per cent. were from three to five years of age inclusive.

In 1,000 cases of disease of the knee joint, 75 per cent. were in the first decade and 40 per cent. were from three to five years inclusive.

In 339 cases of disease of the ankle joint, 70 per cent. were in the first decade and but 35 per cent. were included within the three years.

The distribution of the disease and its relative frequency at the different ages is shown by Alfer's table of statistics from Trendelenburg's clinic at Bonn.[1]

	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	Total.
Vertebræ.....	89	59	32	23	9	10	3	6	3	1	4	0	0	0	239
Hip.....	58	59	43	46	9	11	6	0	4	1	1	3	0	0	241
Knee.....	47	52	47	37	20	11	23	11	11	3	2	8	6	3	281
Ankle.....	5	9	10	5	2	1	1	3	2	0	3	0	2	0	43
Shoulder.....	0	2	2	6	3	5	3	1	1	2	2	1	0	0	28
Elbow.....	7	14	14	21	12	9	6	5	9	8	5	2	2	0	114
Wrist.....	1	0	0	1	5	0	0	3	1	3	2	1	3	0	20
Total.....	207	195	148	159	60	47	42	29	31	18	19	15	13	3	966

This table illustrates the well-known fact that disease of the upper extremity, relatively infrequent at all ages, is proportionately far more common in adult life than is disease of the lower extremity. Of the joints of the lower extremity, the knee and the ankle are proportionately more often diseased in later life than is the hip.

Pathology.—When the bacilli are deposited in a part, the irritation of their toxines causes a proliferation of the fixed cells which lie in direct contact with the germs, and about these a ring of leucocytes forms. The bacilli, the epithelioid cells including often one or more giant cells, together with the surrounding leucocytes, constitute the visible tubercle of bone, a minute grayish speck in the cancellous structure. The central cells about the bacilli, increasing in number, deprived of nourishment and poisoned by the toxines, die and are disintegrated to granular material, "caseate," and the tubercle changes to a yellow color; but the bacilli, multiplying and escaping, form new tubercles about the original focus, which coalesce as the area of the disease enlarges. Meanwhile the surrounding tissue becomes congested, as the result of the irritation, and the fixed cells become organized, or partly organized, into a feeble, ill-nourished form of granulation tissue, representing the effort of the part to shut out and to expel the foreign substances formed by the disease. Or, if this local resistance is effective, the cells become actually organized into firm granulations which surround and destroy the germs, and then are further transformed into

[1] Beit. zür klin. Chir., 1891, Bd. 8, H. 2.

scar tissue. But in most instances either because the irritation is insufficient or because of the deficient vitality of the part, the granulations are feeble and unstable and they in turn become infected and destroyed by the multiplying bacilli, thus serving only to extend the area of the disease. This granulation tissue, before and after the stage of infection, absorbs and destroys the bone. If the progress of the disease is slow, the cancellous structure is completely absorbed or is represented only by bone sand, but if the disease infiltrates the bone more rapidly it may destroy its vitality while its structure is still retained, and a sequestrum is formed. Such sequestra, consisting of rounded, yellow, crumbling masses of cancellous structure, from the size of a pea to a hazel nut, are especially common in epiphyseal disease of childhood. In rare instances, wedge-shaped sequestra are found with the base at the periphery of the epiphysis. These are supposed to be caused by the lodging of an infected embolus in a terminal vessel, which causes the immediate death of the part by cutting off its blood supply.

By the formation of new tubercles at the periphery, and by the caseation of material in the center of the diseased area, a cavity in the bone is formed, containing the débris of the granulation tissue and often sequestra of larger or smaller size, and a variable amount of fluid, made up of serum and leucocytes, that has exuded from the surrounding granulations. The walls of this cavity are formed by the tissue in which the disease is active; the inner layer containing the tubercles in the various stages of formation and decay, the outer, composed of feeble, ill-nourished, granulation tissue as yet not infected, and beyond this the softened and infiltrated bone. If the disease has ceased to progress in any direction, the granulations contain more blood vessels, they are of firmer consistency and more perfectly organized, and the substance of the bone is harder, showing the evidence of repair.

One termination of epiphyseal disease is by enclosure of the focus by resistant granulations, behind which the bone solidifies and shuts in the disease or in favorable cases in which its area is small, completely absorbing and replacing it by scar tissue.

Extra-articular Disease.—As a rule, the tendency of the process is to expand and to force an opening through the cortex of the bone to the exterior. In certain cases this opening may form outside the capsule of the joint, and through it the products of the disease may be discharged into the overlying tissues forming a TUBERCULOUS ABSCESS. Here, the same process of infection and extension of the area of disease continues, but more rapidly than when it was confined within the bone; the surfaces of the muscles and fascia are infected and are covered with an abscess membrane of violet or grayish yellow color, made up of tubercular tissue and masses of fibrin, lying upon, and loosely attached to, the outer inflammatory or healthy granulations.

The cavity of the abscess is distended with tuberculous pus usually of a thin consistency, composed of serous exudation, leucocytes, fibrin, masses of degenerated tissue and fragments of bone or bone sand. It is

commonly of a whitish color, occasionally reddish from mixture with blood, and in the later stages, yellow and serous-like. The abscess enlarges in the direction of least resistance, and in most instances finally perforates the skin by one or more openings through which its contents are discharged. Or, its boundaries may cease to extend, its contents may be absorbed, adhesions may form between its walls, and a spontaneous cure is effected. This course, in which the disease remains extra-articular, is unusual. It is more common at those joints like the knee, elbow and ankle, in which the bones are superficial; it is very uncommon at the hip joint and it is practically impossible in disease of the spine.

PERFORATION OF THE JOINT.—Usually the tuberculous process within the epiphysis, enlarging its area, comes into contact with cartilage, and perforating this finds its way into the joint. While the disease is still confined within the bone, the tissues within the joint are involved in a sympathetic irritation or inflammation. The synovial membrane becomes congested and hypertrophied, the synovial fluid is increased and changed in quality, fibrin forms and is deposited upon the cartilage and upon the lining membrane of the capsule. It is stated by Koenig that the organization of these fibrinous deposits upon the cartilage plays an important part in its destruction, even when actual tuberculous disease is absent. As a result of the sympathetic inflammation within the joint, adhesions may form which may limit the area of the tuberculous disease and retard its progress, after perforation has taken place. This process is similar to the inflammatory changes in the pleura caused by the underlying tuberculous disease.

When the disease comes into contact with the cartilage, it disintegrates; the tuberculous granulations breaking through and spreading over its surface destroy it in piecemeal, or advancing beneath it, separate it from the bone in large, necrotic fragments. The synovial membrane becomes thickened and infiltrated, numerous tubercles appear upon its surface, which undergo the secondary changes that have been described, and the joint becomes, practically speaking, an abscess cavity. The surfaces of the bones are disintegrated by the disease and the destruction is hastened by the pressure and friction due to muscular spasm and to functional use. The thickened capsule, distended by the fluid and solid products of the disease, is usually perforated, and a secondary abscess, communicating with it, is formed in the surrounding tissues. As results of the disease, SECONDARY CHANGES appear in the neighboring parts. The irritation of the periosteum may induce the formation of irregular layers of bone or osteophytes about the joint. A new formation of connective tissue proceeding from the layer of granulations that surround the disease may extend to the muscles and tendon sheaths, binding them together, and causing limitation of motion. The newly-formed connective tissue may be very vascular and irregular in formation, and intermixed with it may be masses of gelatinous or myxomatous tissue. This, according to Krause, is due to the venous stasis and œdematous infiltration caused by the pressure of

the capsular contents and extra-capsular proliferation of granulation tissue. These changes in the appearance and in the consistency of the tissues about the joint are characteristic of the so-called white swelling.

Other Forms of Tuberculous Disease of Joints.—All of the German writers describe forms of primary synovial disease, its frequency varying from 16 to 35 per cent. of the cases. It is more common in adult life than in childhood and at the knee than at other joints. But Nichols[1] states that he has examined 120 tuberculous joints, and has found in every instance one or more foci in the bone that apparently preceded the disease in the joint.

From the clinical standpoint, however, one must recognize a form of disease in which the symptoms differ from the ordinary osteal type. It begins as a chronic synovitis, although the tissues are more thickened and infiltrated than in simple synovitis, and the muscular atrophy is more marked. Reflex spasm and limitation of motion are slight and the symptoms are rather discomfort and fatigue after exertion than actual pain. After many months, when it may be assumed the bones are involved, the characteristic symptoms of tuberculous disease appear. In one form the amount of effused fluid is large, and is clear and serous-like in character—hydrops tuberculosus; but usually it is cloudy, and it may be purulent in character.

As has been stated, Koenig lays stress upon the important part played by fibrin in the changes that take place within a joint. Fibrin deposited from the effused fluid forms in successive layers upon the cartilage. Into this fibrin, vessels grow from the hypertrophied and infected synovial membrane, destroying the cartilage together with the underlying bone. If the synovial disease is primary, the bone is destroyed from without, but if it is secondary to epiphyseal disease it is destroyed from within also.

Arborescent Synovial Tuberculosis.—In this form the interior of the joint is covered with villous proliferations from the synovial membrane. These are formed, it is supposed, by the growth of blood vessels from the membrane into the layers of fibrin that are deposited upon its surface.

Lipoma—Arborescens Tuberculosum.—Arborescent villous proliferations may be formed of adipose tissue covered with synovial membrane which project into the joint.

Rice Bodies.—Rice bodies are numerous small grayish-white bodies resembling cucumber seeds, that are found in certain forms of synovial disease and particularly in tuberculosis of tendon sheaths. They are formed of fragments detached from the proliferating synovial membrane and possibly of simple fibrin, which, under the influence of pressure and attrition in the movements of the joint or of the tendon, assume the characteristic shape and appearance. These bodies within a tendon sheath or joint, cause a peculiar creaking, perceptible to the touch when the part is moved.

Dry Caries—Caries Sicca.—In this form of disease, which is said to be primarily synovial, there is but little formation of fluid and there is

[1] Trans. Am. Orth. Ass'n, Vol. XI.

but little tendency toward cheesy degeneration of the tuberculous products. The infected granulations destroy the bone without forming sequestra, and usually without suppuration. This form more often occurs at the shoulder joint, and it is characterized by marked limitation of motion, extreme atrophy of the surrounding parts, and sometimes by forward displacement of the partly destroyed head of the humerus, that may be mistaken for dislocation.

Septic Infection.—When a tuberculous abscess has opened spontaneously, or when it has been incised, infection with pyogenic germs is common and it occasionally occurs before a communication with the exterior has been established. After such infection the surrounding tissues become infiltrated, reddened, hot and sensitive to pressure. The discharge is greatly increased in quantity and changed in quality. The local pain and discomfort are aggravated and the constitutional effects of pyogenic infection appear. If the area of the abscess is small and if the drainage is efficient, this accident is of slight importance and it may even exercise a beneficial effect in stimulating the circulation and dissolving the effused material about a joint. But if the abscess has burrowed widely into surrounding tissues and if it communicates with an important joint, it is a dangerous complication, in fact the greatest direct danger of tuberculous joint disease. The persistent suppuration exhausts the patient and induces amyloid degeneration of the internal organs ; and by lessening the vital resistance it favors the local advance of the tuberculous disease and its general dissemination.

Repair.—Repair in tuberculous disease may be accomplished by the absorption, ejection or enclosure of the disease. The process of repair usually accompanies the advance of the destructive process and examples of the three methods of cure may be found in a single joint.

The curative agent is the granulation tissue which forms about the area of disease and which finally becoming sufficiently organized to resist the infection of the bacilli, solidifies into fibrous tissue. In those cases in which the disease is not absorbed, or completely thrown off in the abscess formation, but is enclosed, it becomes quiescent. In such cases, under the influence of traumatism, when for example the surrounding adhesions are broken down in the attempt to rectify deformity or to overcome anchylosis, local recurrence of the disease may follow.

Prognosis.—The prognosis will be considered more particularly in the sections on disease of special parts. The danger to life is direct and indirect, and this varies greatly with the part that is affected and with the age of the patient.

In disease of the spine the direct danger to life is greatest, because of its situation since it may involve the spinal cord or extend to the important organs in the neighborhood. Abscess may in rare instances, merely by its size and situation, endanger life and when infected it is far more dangerous because of the difficulty in providing efficient drainage. The influence of deformity and its effect in compressing the internal organs and thus interfering with the vital functions is another more remote element of danger in disease in this situation.

The danger to life from disease of the joints is in proportion to their importance. In rare instances it may extend to the shaft of the bones and set up an extensive osteomyelitis ; or the patient may be weakened by the suffering caused by active disease, but, as has been stated, the most direct and constant danger is from prolonged suppuration that follows septic infection. Danger from this source is much greater at the hip joint than at the ankle or elbow, for example, because of the greater difficulty in preventing the burrowing of pus when infection has occurred.

The indirect danger of tuberculous disease is its dissemination to more important organs. But it by no means follows that the disease of the joint is the source of the general infection.

For as has been stated, it may be inferred that nearly every patient with joint disease has also disease of the lymphatic glands, and in a small proportion of the cases there may be also active disease of important organs. Tuberculosis of the lungs, for example, is often present in the adult before the local outbreak in the joint appears, and it is in great degree because of this liability to disease of the lungs that the prognosis of joint disease becomes progressively worse with the age of the patient.

This point is illustrated by the statistics of Koenig and Bruns on the final results of disease of the knee and hip joints, to which attention will be called again in the special sections. In Koenig's cases of disease of the knee joint the death rate was in patients:

Less than 15 years of age	.....	20 per cent.
From 16 to 30 years	.....	24 "
" 31 to 40 "	.....	44 "
More than 40 "	.....	60 "

In Brun's statistics, the death rate was of patients in the first decade 36 per cent.—in the second decade 44 per cent.—older than this 72 per cent.

The cure of latent tuberculosis in the lymph nodes as well as of active disease of the lungs or bones depends upon the vital resistance of the patient. This vital resistance is lessened by pain, by confinement and lack of exercise. It is directly impaired by the exhausting suppuration and by the poisoning of the toxines incidental to septic infection. Under these conditions the local disease advances and a general dissemination is more probable. This accounts for the fact that death from general tuberculous infection is much more common in this class than when suppuration has been slight or absent. This point is again illustrated by the statistics referred to. The death rate in the cases of disease at the knee without abscess was twenty-five per cent., with abscess forty-six per cent. Death rate in cases of disease at the hip with abscess fifty-two per cent., without abscess twenty-three per cent.

It is probable that tuberculosis may be disseminated by operation upon tuberculous joints, although the evidence upon this point is vague and conflicting. Gibney, contrasting two equal periods of thirteen years of service at the Hospital for Ruptured and Crippled, in the first of which no operations were performed on tuberculous subjects,

states that in his opinion the deaths from this source have been proportionately no greater during the period of active surgical intervention than before. And an investigation of the causes of deaths among the patients treated at the N. Y. Orthopædic Dispensary and Hospital during a period of twenty years, showed that at least twenty-five per cent. of these were due to tuberculous meningitis.[1] During this period there had been, practically speaking, no operative intervention, yet the proportion of deaths from this cause is certainly as great as in any statistics that have been reported. It would appear then that the danger of dissemination is not sufficient to deter one from performing any operation that seems to be indicated by the local disease or by the general condition of the patient.

Treatment.—From what has been stated of the causes of disease it follows that the general treatment should include, if possible, a change in the hygienic conditions, relief from the danger of further infection, pure air and proper food. These are as essential in the treatment of tuberculosis of the bones as of other parts.

As far as the cure of local disease is concerned, no treatment can be as effective as the prompt and thorough removal of the focus of disease, while it is yet limited in extent, and before the joint has become involved. This is practicable, however, in but a small proportion of the cases because it is usually impossible to locate the disease accurately and impossible to remove it without sacrificing much of the healthy bone upon which the future usefulness of the part depends. At one time early operation, even complete excision of the joint, was justified on the plea that the disease might thus be eradicated. But now that it is known that in nearly all cases other tuberculous foci exist in the body, and as the functional results after these early operations are far inferior to those attained under conservative treatment, early excisions are limited to the adolescent or adult cases. For in this class growth has been attained and the economic conditions require that the period of disability should be as short as possible. Local treatment is therefore conducted with the aim of relieving the part of function, that is to say from strain and injury. Functional use of a diseased joint delays natural repair, since it causes pain and thus reduces the natural forces, while it stimulates the disease and increases its destructive action. The details of treatment will be described in the consideration of disease of special joints.

Treatment by Drugs.—The administration of drugs occupies a very subordinate place in treatment, since it is not believed that any drug exercises a direct action upon the local disease in the bone.

Cod-liver oil, the hypophosphites, the various preparations of iron or other tonics may be given at certain times with benefit, but the continuous administration of medicine during the years that are required to complete a cure is, of course, out of the question.

Local Applications. Iodoform.—Iodoform is supposed to exercise a direct germicidal action and also to stimulate the formation of the gran-

[1] Personal communication from Dr. David Bovaird.

ulations that cast off or absorb the tuberculous products and then become transformed into fibrous tissue. At one time direct injection of the remedy into the bones was advocated, but this has now been abandoned, and its use is practically limited to the treatment of tuberculous abscesses. Iodoform is ordinarily employed in an emulsion with glycerine or oil, 10 cc. of 10 per cent. mixture being injected at intervals of two or more weeks. Several deaths from iodoform poisoning have been reported, but injections of this quantity of the drug are apparently free from danger.

Carbolic Acid.—Carbolic acid in dilute solutions was at one time injected into tuberculous cavities, but its use has been generally discontinued because of the danger of poisoning. Recently Phelps has advocated the use of pure carbolic acid in the treatment of tuberculous abscesses and sinuses. This is injected into the fistulæ or into the abscess cavity, which has been opened, and is allowed to remain for about a minute, when it is neutralized by copious injections of alcohol, after which the part is thoroughly cleansed by salt solution. Carbolic acid doubtless acts as a caustic, destroying the infected granulations and stimulating the reparative processes. Other remedies of this class, for example, tincture of iodine, chloride of zinc, actual cautery and the like, are also used and in certain cases with benefit. In the treatment of tuberculous ulcerations ichthyol, balsam of Peru and iodoform are among the drugs employed. Balsam of Peru dissolved in castor oil of a strength of about 10 per cent. as suggested by Van Arsdale, is a very satisfactory application.

Venous Stasis—Bier's Treatment.—Bier's treatment of tuberculous joint disease was suggested by the observation of Rokitanski, that phthisis was uncommon in individuals suffering from disease of the heart when the mechanical obstruction was sufficient to cause venous congestion of the lungs.

This treatment, by means of venous stasis, is conducted as follows: A rubber bandage is placed about the limb above the joint, under sufficient tension to interfere with the return of the venous blood; and in order to limit the congestion to the diseased part, the limb is firmly bandaged with a flannel bandage up to the joint, from below. Between the two the tissues about the joint become swollen, the local temperature is increased and the color of the skin becomes bluish red. At first the congestion is continued for short periods only during the day, as it is somewhat painful. These are lengthened, until finally it may be applied continuously.

If the disease is active the treatment may hasten abscess formation, and if sinuses are present the discharge is usually increased for a time. The venous congestion is supposed to stimulate the formation of healthy granulations and their further transformation into fibrous tissue; and according to the investigations of Hamburger, the serum of venous blood has a distinct germicidal property. The treatment may be applied most conveniently at the knee and ankle joints, but if applied it should serve merely as an adjunct to mechanical protection.

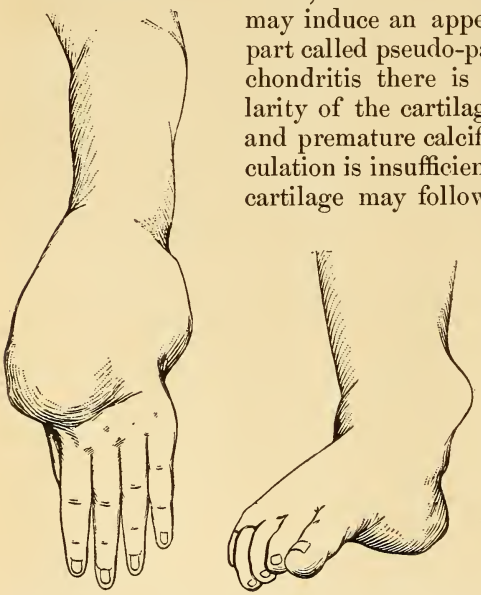
CHAPTER VI.

NON-TUBERCULOUS DISEASES OF THE JOINTS.

Syphilitic Disease of the Joints.

In early infancy the characteristic syphilitic disease of the bones is a form of osteochondritis. Painful, sensitive swellings appear at the epiphyseal junctions, either as small, hard tumors or as general enlargements, resembling those of rhachitis. (Fig. 145.) As a rule several epiphyses are involved, more often those at the distal extremities of the bones of the lower limbs, and in these cases the pain and discomfort may induce an appearance of helplessness of the part called pseudo-paralysis. (Parrot.) In osteochondritis there is a multiplication and irregularity of the cartilage cells of the ossifying layer and premature calcification. As a result, the circulation is insufficient and necrosis of a part of the cartilage may follow, which, acting as a foreign body, sets up inflammatory changes in the adjoining parts. The process is shown by a zone of hard, dry yellow substance in the ossifying layer, adjoining which is an inflammation of the tissues of the newly formed bone which is in part transformed to granulation tissue. If the disease is progressive ulceration and suppuration may follow, the cartilage may be destroyed and the epiphysis may be separated causing deformity and cessation of growth. The neighboring joint is usually involved in the disease. In the milder cases there is a simple sympathetic synovitis; in the advanced class a destructive arthritis. In one case seen recently, the symptoms of pain on motion combined with slight effusion into several joints were present without the epiphyseal enlargement. The affection may be distinguished from rhachitis by the accompanying symptoms

Fig. 145.



Suppurative syphilitic epiphysitis at lower ends of radius and tibia in an infant aged one month. The child died shortly after the drawings were made, and the epiphyses were found lying loose in purulent cavities. (Tubby.)

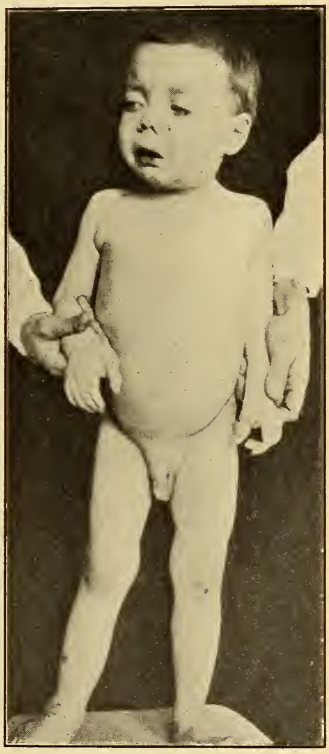
of syphilis, by the irregularity of the epiphyseal involvements and by the age of the patient and the absence of the other symptoms of rhachitis.

In the LATER MANIFESTATIONS OF HEREDITARY SYPHILIS, in which the bones in the neighborhood of the joint are involved in syphilitic osteoperiostitis, the joint may be sympathetically affected or the disease may actually perforate the joint. A slow, chronic, infiltrating gummatous form of disease appearing in later childhood may simulate very closely the appearances of so-called white swelling. It is more common at the knee, but other joints are often affected as well.

FIG. 146.

Syphilitic osteo-periostitis of the tibiæ resembling anterior bow leg. This is the most characteristic manifestation of hereditary syphilis.

FIG. 147.



Syphilitic disease.

In the SECONDARY STAGE OF ACQUIRED SYPHILIS, pain and swelling of the joints, resembling rheumatism, may be present, and in tertiary syphilis the joint may be involved in disease of the neighboring bones, or the joint itself may be primarily implicated.

In most instances the joint affections of syphilis are explained by the history and by the other signs of syphilitic disease. Spina ventosa (Fig. 147), which is classed as one of the evidences of syphilis, is far

more commonly of tuberculous origin, as is illustrated by the statistics of Karewski,[1] of 157 cases, in which but three were due to syphilis.

Syphilitic disease of the joints is very uncommon in orthopædic clinics as compared with those of tuberculous origin. This is as might be expected, for not only is tuberculosis far more common than syphilis, but a very large proportion, according to Fournier, 77 per cent., of the syphilitic children are born dead or die shortly after birth. Even in those that survive, disease of the bones or joints in the form that could be confounded with tuberculosis, is uncommon as compared with its other manifestations.

Some writers consider hereditary syphilis to be a very important predisposing cause of tuberculous disease, and believe that many cases classed as tuberculous are in reality syphilitic, even if no history or confirmatory signs of syphilis be present. There is no reliable evidence to support this view. The possibility of the syphilitic taint, remote or direct, should be borne in mind, and in doubtful cases appropriate remedies should be employed; but whether the disease of joint be syphilitic or not the same protective treatment is indicated that would be applied under other circumstances.

GONORRHŒAL ARTHRITIS.

Synonym. **Gonorrhœal Rheumatism.**—So-called gonorrhœal rheumatism is an inflammation of a joint caused by the presence of gonococci. It is said to complicate from two to five per cent. of all the cases of gonorrhœa, usually appearing in the later stages of that affection, and it is more common among those who are in a debilitated condition.

Distribution.—In about 40 per cent. of the cases it is monarticular and the knee joint is most often involved. In 375 cases collected by Finger, the distribution was as follows:[2]

Knee	136	Shoulder	24
Ankle	59	Hip	18
Wrist	43	Jaw	14
Finger joints	35	Other articulations	21
Elbow	25		375

Bennecke[3] has tabulated 78 cases recently under treatment. The 78 cases occurred in 56 patients, of whom 18 were males, 38 females. The distribution was as follows:

Knee	31	Shoulder	4
Hip	8	Elbow	10
Ankle	9	Wrist	6
Other joints of foot	6	Fingers	4
			78

Symptoms.—The affection is usually of a subacute character. The joint becomes swollen and there is discomfort, particularly weak-

[1] Chir. Krank. des Kindesalters.

[2] Taylor, Ven. Diseases, p. 263.

[3] Die Gon. Gelenkentzündung nach beob., der Chir. Univ. Klin. in der K. Charité zu Berlin. Hirschwald, Berlin, 1899.

ness, and stiffness on use; but if the infection is more severe there may be local heat, pain and infiltration of the tissues with accompanying muscular spasm.

Gonorrhœal arthritis has been divided into three classes according to its symptoms and physical characteristics: The serous; the sero-fibrinous; the purulent.

The SEROUS FORM is, as its name implies, a simple effusion resembling other forms of subacute synovitis, although it is of a more chronic character.

The SERO-FIBRINOUS VARIETY is of a more serious character, the so-called plastic type of inflammation. In this form fibrin may be deposited upon the cartilage which is afterwards organized by the growth of vessels into it from the synovial membrane, a process which erodes the cartilage upon which the granulations rest. The folds of the synovial membrane adhere to one another, the capsule is thickened and ligaments and tendons may be involved in the adhesive inflammation. These changes within and without the joint may seriously impair its function after the cure of the active disease.

The PURULENT FORM is uncommon; it is similar in its characteristics to suppurative arthritis from other causes. It is attended by great local heat, pain and swelling and by constitutional disturbance.

FIG. 148.

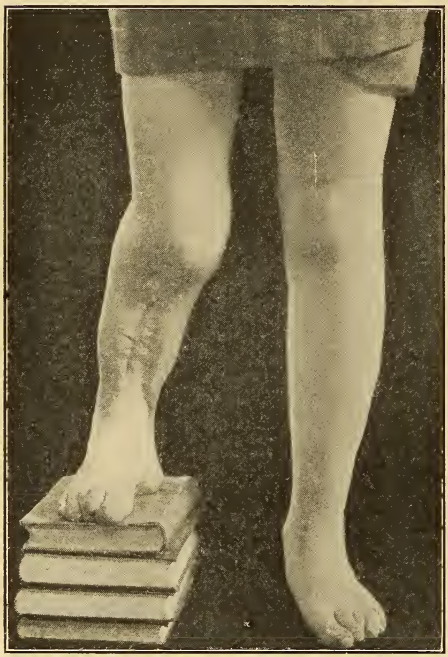
Deformities resulting from infectious osteomyelitis.

In orthopædic clinics gonorrhœal arthritis is usually seen in its later stages when the acute symptoms have subsided. In these cases, swelling and pain persist, in many instances, and in the more severe class motion is limited or the limb may be fixed in an attitude of deformity. An obstinate, monarticular, painful swelling of a joint suggests gonorrhœa, and its presence or absence should always be determined, since the effective treatment of the primary cause is essential

to the cure of the secondary affection of the joint. The same statement is true of painful, persistent affections of bursæ and tendon sheaths, and of obstinate forms of weak foot.

Treatment.—The treatment of the early stage of this form of arthritis is rest and compression with hot or cold applications as may seem to be indicated. If the symptoms are acute and if there is constitutional disturbance, the joint should be aspirated, and if the examination shows the effusion to be sero-purulent, it should be treated by incision and drainage. In the chronic form also, when the capsule is distended by the sero-fibrinous effusion, incision and removal of the contents is indicated.

Fig. 149.



Loss of growth following osteomyelitis of the tibia.

In the latter stages of disease of the ordinary subacute type, the treatment is directed to the absorption of the effused material within and without the joint, and to the restoration of functional activity. The use of hot air, massage, the hot and cold douche and the like are of service in stimulating the circulation. If the limb has become deformed, and if it be fixed by adhesions and by contractions, the distortion may be corrected by forcible manipulation under anæsthesia which will serve to rupture the adhesions as well. And it may be stated that this class of cases is the most encouraging from the standpoint of restoration of function by this means.

If, however, the limb is fixed in the proper position it is well to postpone forcible measures until the effect of the massage and gentle passive movements have been observed.

Functional use is the most effective treatment, and this is made possible by the employment of apparatus by which the exact amount of motion that the joint will allow without discomfort, may be permitted.

Other Forms of Infectious Arthritis.

Puerperal arthritis, resembling that caused by gonorrhœa may occur. It is usually of a more severe type as it is often caused by mixed infection.

Arthritis Following Infectious Disease.—The joints may be

involved in the course of any infectious disease. A mild form of arthritis often involving several joints, is particularly common after DIPHTHERIA OR SCARLATINA.

Localized and destructive forms of suppurative arthritis also occur. Arthritis following TYPHOID FEVER, is usually of a severe and destructive type. Keen[1] has tabulated 84 cases. In 43 per cent. of these the hip joint was affected and in 40 per cent. spontaneous dislocation occurred. In a case treated recently at the Hospital for Ruptured and Crippled there had been a destructive arthritis of one hip joint, spontaneous displacement of the femur on the other side and secondary contractions at the knees and ankles, so that the patient was bedridden.

Treatment.—The treatment in all forms of arthritis complicating diseases of this class, is to place the affected joint at rest, and to prevent the secondary distortions that lead to fixed deformities.

Spontaneous dislocation which is comparatively common when the hip joint is suddenly distended with fluid, is not likely to occur unless the limb is flexed and adducted. This attitude should be prevented by the use of traction or support.

The presence of pus is of course an indication for operative intervention, and in all doubtful cases the character of the effusion should be ascertained by aspiration.

ACUTE ARTHRITIS OF INFANCY.

Acute Epiphysitis.

A form of acute suppurative arthritis primarily within the joint or more often secondary to disease of the neighboring epiphysis, is not uncommon in infancy.

Etiology.—The disease may be caused by staphylococci, or streptococci, or by mixed forms of infection. In the early weeks of life it may follow infection of the umbilicus. It may be secondary to one of the exanthemata or to gonorrhœa, but in many instances the origin is not apparent. Falls or blows upon the part appear to be predisposing causes.

Townsend[2] tabulated seventy-three cases of acute arthritis, eighteen of which were personal observations. To these I am able to add twelve others, making a total of eighty-five cases. In sixty-four of these the infection was monarticular, in twenty-one more than one joint was involved. The distribution was as follows:

Hip joint	45	53 per cent.
Knee "	32	37 "
Other joints	8	10 "

The sex was specified in sixty-one cases. Males, thirty-eight; females, twenty-three.

[1] Surgical Complications and Sequels to Typhoid Fever.
[2] Am. Jour. Med. Sci., Jan., 1890.

Symptoms.—If the infection is severe there is immediate local heat, redness, swelling and œdema, great pain and corresponding constitutional disturbance. But in many instances the local and general symptoms are less marked and several weeks may elapse before the patient is brought for treatment.

Treatment.—The treatment is of course free incision and drainage. The part must be supported during the active stage of the disease ; an apparatus is usually required to prevent deformity or to support the weak limb when the patient begins to walk.

Prognosis.—If the arthritis is a primary disease within the joint complete recovery may follow evacuation of the pus, but as a rule the neighboring epiphyseal junction is diseased, suppuration is prolonged and a part of the epiphysis is destroyed before the disease comes to an end ; thus subluxation or displacement with subsequent deformity and loss of growth are the usual results of this form of disease. At the hip joint, for example, the laxity of the ligaments and the upward displacement of the femur that follow destruction of the head of the bone, cause symptoms that are often mistaken for those of congenital dislocation.

In some of the cases there is, in addition to the arthritis, an osteomyelitis of the shafts of one or more of the bones. These cases are usually fatal, or if the patient survives, there is usually necrosis of the affected bones and consequently extreme deformity.

In the cases reported by Townsend the death rate was in the monarticular form, eighteen per cent.; in the multiple form, seventy-three per cent.

Acute Tuberculous Arthritis.—In early infancy forms of acute tuberculous disease, especially at the knee joint, may simulate closely infectious arthritis. The knee may be swollen, hot and sensitive to pressure and the onset may be sudden and accompanied by constitutional disturbance. Such cases are more often observed in the children of mothers in whom there is advanced disease of the lungs.

Localized Infectious Osteomyelitis.

In older subjects localized osteomyelitis in the neighborhood of a joint may simulate tuberculous disease. The onset of the affection is however more abrupt, the surrounding tissues are infiltrated and the symptoms are usually more acute than in the latter affection. In such cases operative intervention is indicated.

Osteo-arthritis.

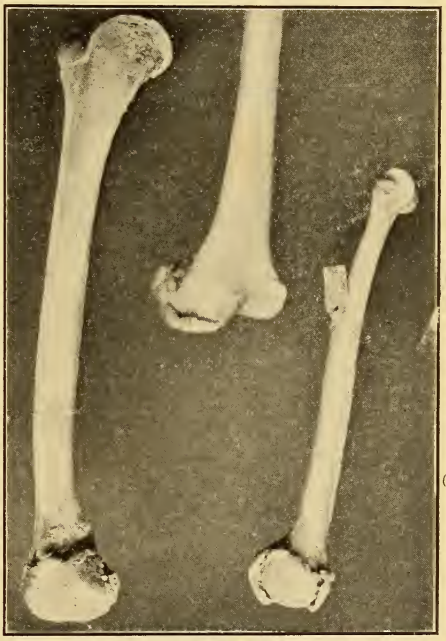
Synonyms.—Arthritis Deformans, Rheumatoid Arthritis.

Osteo-arthritis is a chronic destructive disease of the joints resembling rheumatism somewhat in its distribution and clinical history.

Pathology.—The disease appears to begin in the cartilage which becomes fibrilated and destroyed in the parts subjected to greatest pressure, while it is thickened and heaped up into irregular layers at the periphery, as if under the influence of pressure it had been squeezed out

from the interior of the joint. (Fig. 150.) The process is supposed to consist in a multiplication of the cartilage cells which in the free portion of the cartilage escape into the joint while in those parts covered by synovial membrane they are retained. When the cartilage disappears the bone deprived of its natural protection is worn away, and under the influence of pressure and friction it becomes increased in density and hardness, "eburnated." Meanwhile the hypertrophied cartilage at the periphery becomes in part ossified. Thus the contour of the bones and their mutual relation to one another are changed. The synovial membrane becomes hypertrophied and its villi, some of which may contain cartilaginous nodules, project into the joint in shaggy fringes. These may be detached from time to time and may form loose bodies within the capsule. The synovial fluid may be greatly increased in quantity, distending the capsule or, communicating with bursæ, it may form cysts, as is sometimes observed at the knee joint. But more commonly the fluid is decreased in amount. The ligaments are weakened and destroyed and the tendons about the joint become adherent to their sheaths and to the neighboring tissues. The muscles atrophy and become contracted and structurally shortened in accommodation to the deformity.

FIG. 150.



Arthritis deformans, from the Museum of the College of Physicians and Surgeons, New York.

ETIOLOGY.—The subject is as yet very imperfectly understood, and the terms osteo-arthritis and rheumatoid arthritis, which are usually considered as synonymous, probably include a number of pathological conditions. The etiology is uncertain. Malnutrition, exposure to cold and wet, infectious diseases and a peculiar condition of the nervous system are considered as predisposing causes, and recently it has been claimed that the disease is of germicidal origin, but this is doubtful. Injury may be a predisposing, as it certainly is an exciting, cause in the monarticular form.

Varieties.—Osteo-arthritis may be divided, from the clinical standpoint, into the MULTIPLE and the LOCALIZED forms.

MULTIPLE OSTEO-ARTHRITIS may be acute, subacute or chronic.

In the acute variety the disease may resemble rheumatism, but the

ordinary form is the subacute or chronic, which may progress slowly, involving one joint after another until the patient may be crippled by the limitation of motion in the joints, and by the secondary distortion of the limbs.

The affection is far more common among females than males, and it usually begins in early middle life, although it is not particularly infrequent in childhood. In one case, seen at the Hospital for Ruptured and Crippled, the patient was less than four years old, and several patients have been treated in the wards who were less than ten years of age.

In 500 cases of the multiple form tabulated by Garrod,[1] the distribution was as follows :

The hands	were involved in	86	per cent.	of	the	cases.
" knees	"	" 60.6	"	"	"	
" feet	"	" 34.4	"	"	"	
" ankles	"	" 27.4	"	"	"	
" wrists	"	" 26.6	"	"	"	
" shoulders	"	" 25	"	"	"	
" elbows	"	" 25	"	"	"	
" hips	"	" 14.6	"	"	"	
Temp. max. artic.	"	25	"	"	"	
Cervical spine	"	35	"	"	"	
Dorsal spine	"	3	"	"	"	
Sterno-clavicular artic.		4	"	"	"	

Another form of osteo-arthritis of comparatively slight importance is that in which the disease is confined to the joints of the fingers. The bases of one or more of the distal phalanges become enlarged (Heberden's nodosities) and the fingers become somewhat stiff and painful. Gradually other phalangeal joints become involved until the fingers become deformed and function is somewhat interfered with, although never to the extent that is observed in the multiple form in which the fingers are dislocated and distorted.

As has been stated, the disease is usually progressive, periods of quiescence alternating with exacerbations of pain and discomfort, at which times the disease progresses.

The Localized Form.—The localized form of osteo-arthritis, although similar in its pathological appearances, differs from the multiple variety in that it is more common in men than in women, and that injury appears to have a distinct influence in its causation.

The affection may be limited to one of the large joints, the hip, the knee or the shoulder, while the hands, that are almost invariably involved in the multiple form, remain free from disease.

The Atrophic Form.—In the description of the pathology of osteo-arthritis it has been stated that the disease is characterized by proliferation of cartilage, and by hypertrophy combined with destruction of the bone. There is, however, another variety of disease resembling this form closely in its symptoms, in the quality of the

[1] Twentieth Century Practice.

patients who are subject to it and in its distribution, being both multiple and monarticular, but differing from it in its pathological anatomy. In this form there is no hypertrophy but an actual atrophy of the bone entering into the formation of the joint. In the active stage of the disease the joints are swollen, infiltrated and thickened, but this thickening is practically limited to the soft tissues outside the joint, and after the acute stage has passed the stiffened joints may be actually smaller than before. Thus osteo-arthritis includes two varieties of disease from the standpoint of the pathological characteristics, the hypertrophic and the atrophic.

Goldthwait[1] suggests that the term osteo-arthritis might be limited to the hypertrophic form, while the other variety, characterized by stiffening of the joints without marked destruction or lateral displacement, might be classified as rheumatoid arthritis. It is doubtful, however, if a sharp distinction can be drawn between the two. In childhood, for example, there may be great destruction and displacement of the finger joints without hypertrophy which, in fact, is almost never observed in this class. Again in the early stage of osteo-arthritis it is practically impossible to distinguish the hypertrophic from the atrophic form. It is possible, also, that the two varieties may be combined in the same individual, or that either form may be complicated by ordinary rheumatism.

Symptoms.—The symptoms are discomfort and pain more marked in damp weather or after over-exertion ; stiffness on changing from rest to activity and creaking sensations apparent on palpation. Motion is restricted by muscular spasm and contraction and by the mechanical effects of the disease within and without the joint, and finally the limb may become fixed in an attitude of deformity. In the spine, the deformity is usually a long posterior curvature and the vertebræ are firmly fixed by growth of periosteal bone, or if the cervical region is diseased the head may be distorted. (See spondylitis deformans.) At the hip joint there is wearing away of the head of the bone and upward enlargement of the acetabulum, so that a form of pathological coxa vara or subluxation appears, and the limb is usually somewhat flexed and adducted. This condition is sometimes mistaken for fracture of the neck of the femur, especially when the symptoms have been aggravated by injury. A similar pathological condition may occur at the shoulder.

Treatment.—The treatment should be directed to improving the general condition of the patient and protecting him from exposure to sudden changes in temperature. Locally the disease may be favorably influenced by massage, by hot air, by static electricity and the like, measures which doubtless serve to improve the local nutrition and thus the resistance of the affected part. The application of the actual cautery and the protection assured by flannel bandages, add greatly to the comfort of the class of patients seen in hospital practice.

If deformity is present it may be overcome if necessary by forcible

[1] Boston Med. and Surg. Jour., Jan., 1897.

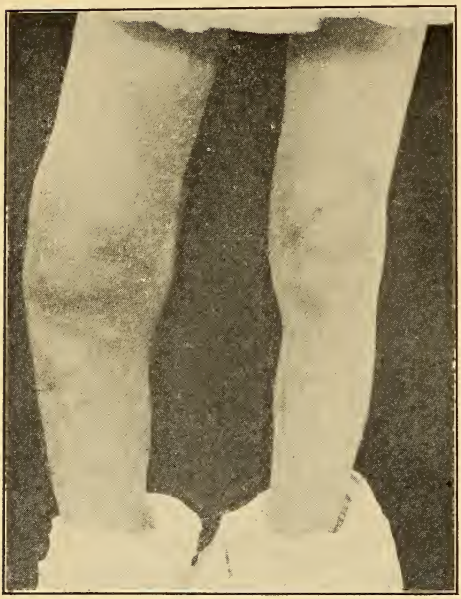
manipulation under anæsthesia, after which the improved position may be assured by proper apparatus. This treatment is much more useful, according to Goldthwait, in the atrophic than in the hypertrophic form of the disease. In cases in which the anchylosis is resistant or when the joint is disabled it may be excised. This operation has been performed with success at the knee; and by it motion has been restored at the elbow in cases reported by Collinson, Bannatyne and Southam.[1] In one case treated at the Hospital for Ruptured and Crippled the function of the jaw was restored completely by excision.

In the localized form, apparatus to protect the part from strain and injury and to prevent deformity, is sometimes of great service. And in certain instances exploration of the joint which would permit of the removal of hypertrophied tissue might be of service.

Hæmophilia—Hemarthrosis.

Hemorrhage into a joint may occur in a so-called "bleeder." In this class, practically limited to the male sex, the knee joint is most often involved. As a rule it is the result of injury and if the peculiarity of the patient is known, the nature of the effusion may be suspected. In some instances there is no history of traumatism and the swelling may be accompanied by fever. This is probably the effect of the hemorrhage rather than its cause.

FIG. 151.



Charcot's disease of the knee joint.

The peculiar interest in the affection, aside from the importance of a proper diagnosis, lies in the fact that the further organization of the effused blood may cause symptoms, and changes about the joint, that may be mistaken for those of tuberculous disease. There may be, for example, persistent swelling, thickening of the tissues, limitation of motion and deformity combined with more or less weakness and discomfort. These symptoms are explained by the irritation of the effused blood and by its further absorption and organization which necessitates the formation and growth of new blood vessels; practically a granulation tissue is

[1] Lancet, Nov. 4 and Dec. 9, 1899.

formed that may erode the cartilage upon which the fibrinous deposits rest. These secondary changes resemble the early stage of osteo-arthritis.

Treatment.—The treatment is rest and protection. Several deaths have been reported from hemorrhage after operative intervention in cases in which the affection had been mistaken for tuberculous disease.

Hemarthrosis.

Hemorrhage into a joint caused by traumatism, complicating synovial effusion, is sometimes followed by the same persistence of symptoms, and it may be, by the destructive changes that result from the effusion in hemophilia. This suggests the advisability of incision and removal of the blood clot, in order to relieve the part of this unnecessary process.

Scorbutus—Scurvy.

This affection is sometimes attended with hemorrhage into and about the joints. It will be considered in connection with infantile rhachitis.

Charcot's Disease.

Charcot's disease is a form of arthritis which is secondary to locomotor ataxia.

Pathology.—It resembles somewhat in its pathology osteo-arthritis. The cartilage degenerates and, together with the underlying bone, is worn away by the movements of the limb. Accompanying the destructive process there is an exaggerated and irregular formation of cartilage and bone about the periphery of the joint. The synovial membrane is hypertrophied and may be covered in places with calcareous plates; the contents of the joint is usually increased in quantity.

The joint disease usually appears early in the course of locomotor ataxia often before its existence is suspected and it is sometimes caused by injury.

Charcot's disease is said to affect from five to ten per cent. of the ataxic patients; it is more common in the lower extremity and one or more joints may be involved. In the cases tabulated by Flatow the distribution was as follows:

Knee	60	; in	13	cases	both knees.
Foot	30	; "	9	"	" feet.
Hip	38	; "	9	"	" hips.
Shoulder	27	; "	6	"	" shoulders.[1]

Symptoms.—The symptoms are the swelling due to the effusion, laxity of the ligaments and deformity. There is but little pain and the patient's chief complaint is of the weakness and distortion of the limb. In certain cases the progress of the affection is very rapid and the destruction of bone may be so extensive that there is an actual luxation at the affected joint.

Diagnosis.—If the patient is known to have locomotor ataxia the diagnosis will be evident, and in any case the peculiar enlargement

[1] Deutsche Chir., L. 28, 1900.

and thickening of the tissues, together with its excessive laxity of the ligaments, characteristic of this affection, which has been called a caricature of osteo-arthritis, should call attention to the disease of the spinal cord.

Treatment.—The treatment of the disease is efficient support (Fig. 152) for the joint, to prevent progressive distortion. Excision of the knee has been performed, but in many cases the bones have failed to unite, and on this account the operation is contraindicated.

Disease of joints SECONDARY TO OTHER FORMS OF DISEASE OF THE NERVOUS SYSTEM may occur. It is most common as a complication of syringomyelia, in which, in contrast to locomotor ataxia, the joints of the upper extremity are far more often involved than of the lower.

In Schlesinger's cases the distribution was as follows:[1]

Shoulder	29
Elbow	24
Wrist	18
Hip	4
Knee	7
Foot	7
Other joints	8
	97

In all forms of joint disease secondary to disease of the nervous system, the influence of injury on the ill-nourished or ill-protected part is recognized in the causation and in the progress of the disease.

This indicates the principles of local treatment.

Anchylosis.

Anchylosis implies fixation in an attitude of deformity, and the term should be restricted to practical fixation caused by tissue changes within or without a joint, but it is often incorrectly applied to limitation of motion such as may be caused, for example, by muscular spasm.

Etiology and Pathology.—Anchylosis may be the result of actual union of two bones whose cartilages have been destroyed, a synostosis. This is sometimes called true, as distinguished from false or fibrous anchylosis.

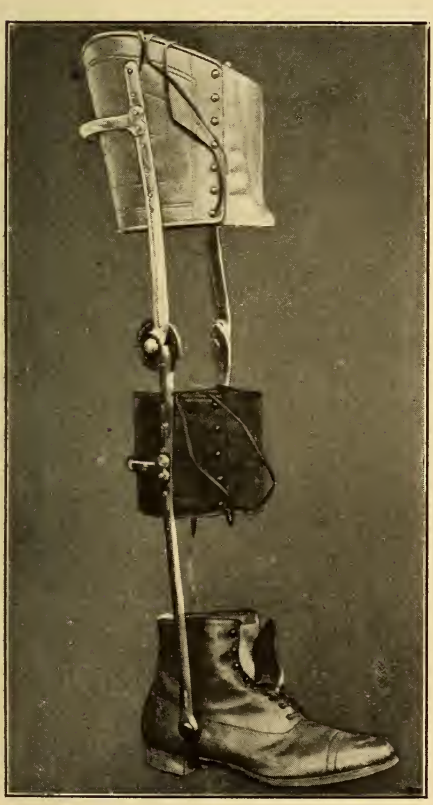
It may be caused by adhesions between the folds of synovial membrane, by adhesions and contractions of the capsular and other ligaments, by adhesions between the tendons and their sheaths, by the general adhesions and contractions caused by burrowing abscesses and by the retraction and structural shortening of muscles when the deformity has persisted for a sufficient time. It may be caused also by fractures or dislocations or by marginal exostoses.

Anchylosis is usually secondary to an inflammatory affection of the joint during which the adhesions have formed, within and without the capsule, and if deformity has been allowed to persist the muscles may have become atrophied and structurally shortened as well.

[1] Die Syringomyelie, Wien, 1895.

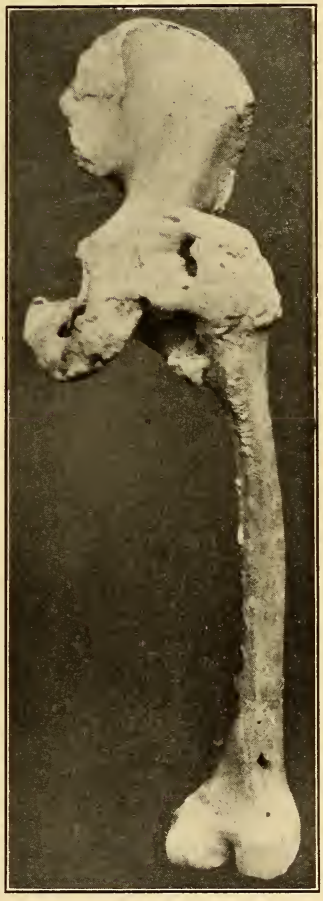
Prevention and Treatment.—The danger of anchylosis may be lessened by the proper treatment of the disease of which it is a result. In tuberculous disease, for example, motion may be preserved in many instances by efficient protection, by which the area of the disease is restricted and its destructive effects checked. In this class of cases the joint should be fixed, during the progressive stage of the disease, in the attitude in

FIG. 152.



A useful form of brace for weak knee. The Campbell brace. (SHAFFER.)

FIG. 153.



Anchylosis at the hip, showing masses of new bone. (From the Museum of the College of Physicians and Surgeons.)

which anchylosis, if it be unavoidable, will least inconvenience the patient.

Formerly it was believed that prolonged fixation of a tuberculous joint would of itself induce anchylosis, but now that it is known that final limitation of motion is dependent upon the severity and the duration of the disease, prolonged rest is believed to be the most efficient means of assuring final motion.

In this class of cases, when the disease is cured, functional use will

ordinarily restore all the motion of which the part is capable. In other inflammatory affections of the joint which are usually of infectious origin, the violence of the acute process may be restrained by rest, or by the removal of the contents of the joint if the infection is severe.

Passive Motion.—When the acute symptoms have subsided the absorption of the plastic material may be hastened by massage, the hot air bath and the like, and by carefully regulated passive and active motion. In the final stage, when there is no longer evidence of active disease, passive movements under anæsthesia may be of service in breaking adhesions, especially if these are without the joint. Passive movements that cause persistent discomfort or pain, which are often employed in the treatment of stiff joints, even when the disease is active, are absolutely contraindicated. If however, the limb during the course of the disease has become deformed, it should be restored to its proper position as soon as possible even though force is required. This treatment is indicated in order to prevent secondary retraction of the muscles and fasciæ.

Forcible Correction.—The class of cases, in which the limb has become fixed in deformity, is the most favorable class on which to perform so-called brisement forcé because the rectification of deformity is always indicated, and in accomplishing this there is always the prospect of regaining a certain degree of motion. If, however, there is no deformity the advisability of forcible motion will depend on the character of the preceding disease, as well as upon the condition of the joint. It is rarely advisable to disturb a tuberculous joint or at least not until long after the cure of the disease, but if the anchylosis has followed infectious arthritis of a mild form, or monarticular rheumatism, forcible manipulation may be attempted. If under gentle manipulation the adhesions give way suddenly, allowing free motion, the prognosis is good, but if there be a peculiar elastic continuous resistance, as when there are extensive adhesions within the joint, there is little likelihood of attaining motion by this means. If but slight force has been exerted there is usually but little reaction, and massage and passive motion may be employed at once; but in other instances the manipulation is followed by swelling and pain, and until these symptoms have subsided fixation may be indicated. Afterwards, passive movements within the range that is practically painless, and functional use, when the part is protected by apparatus which limits the range of motion to the painless area, are of service. The X ray is of service in indicating the condition of the joint, but the history of the disease and the physical examination which shows its destructive effects, is of more value. In some instances operative exploration of the joint may be indicated. This permits the removal of exostoses or displaced fragments of bone after fracture that may limit motion mechanically. True bony anchylosis in the lower extremity admits of no remedy as far as the restoration of joint function is concerned, although the symmetry of the limb, if it be deformed, may be restored by osteotomy. But in the upper extremity, motion may be gained by excision of the joint and in some instances this is advisable.

CHAPTER VII.

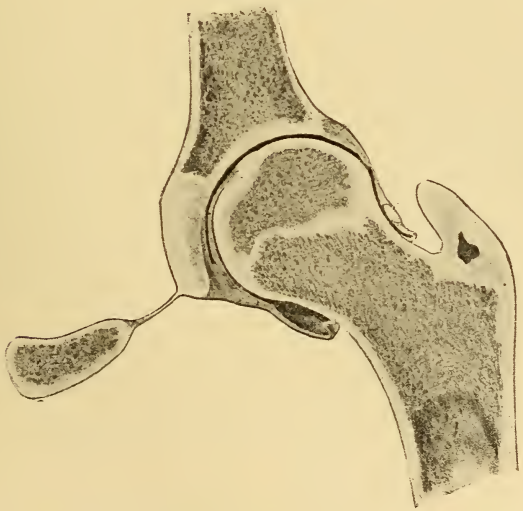
TUBERCULOUS DISEASE OF THE HIP JOINT.

Synonyms.—Hip Disease, Morbus Coxæ.

Hip disease is a chronic destructive disease that results in loss of function and deformity. At one time a number of pathological processes and even simple deformity (coxa vara) were included under the title, but it is now limited to tuberculous disease.

Pathology.—Tuberculous disease of the hip joint usually begins in several minute foci in the neighborhood of the epiphyseal cartilage of the head of the femur. Here the circulation is most active and here

FIG. 154.



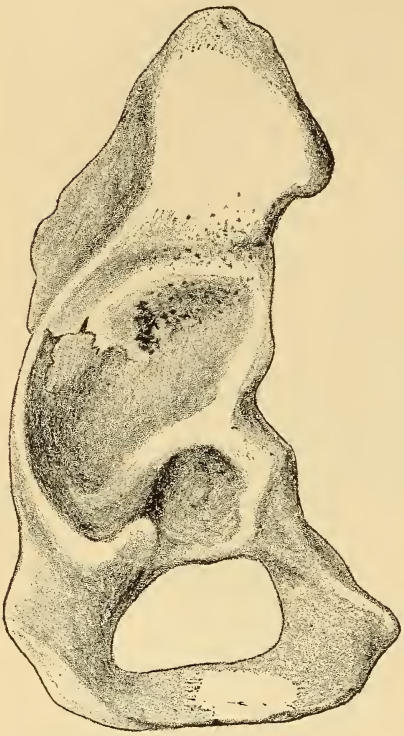
Section of the hip joint at the age of six years. (SCHUCHARDT.)

the newly formed bone is least resistant. Thus the bacilli, carried by the blood, are more often deposited at this point where, under favoring conditions, induced it may be by slight traumatisms, the disease is established. These foci coalesce and an area of infected granulations replaces the normal structures. If the local resistance is sufficient, the disease may be confined to the interior of the bone, but in most instances it gradually forces its way into the joint, and the granulation tissue spreading under and over the cartilage, destroys it in its progress. The lining membrane of the joint becomes involved in the disease and finally the adjoining surface of the acetabulum as well. In a certain

indeterminate number of cases, the tuberculous process begins about the epiphyseal junctions in the acetabulum, and primary disease of the synovial membrane may occur, although this is certainly uncommon in childhood.

From the clinical standpoint, primary disease of the acetabulum may be inferred when the patient is particularly susceptible to movements of the trunk, or when lateral pressure on the pelvis causes pain; or when a Roentgen picture shows greater erosion of the acetabulum than of the head of the femur. (Fig. 168.) There are certain cases also, in which the symptoms of the disease are slight and in which the swelling of the joint is well marked; in such cases it is probable that disease of the synovial membrane is present, unaccompanied by marked involvement of the head of the femur or of the acetabulum. As a rule, however, the symptoms may be best explained by primary disease of the head of the femur.

FIG. 155.



"Wandering of the acetabulum" in hip disease. (KRAUSE. Deutsche Chir., L. 28 a.)

While the tuberculous process is still confined within the bone, the joint shows evidences of sympathetic irritation; the synovial membrane is congested and the fluid within the joint is increased in quantity. These changes become more marked as the disease progresses, the membrane becomes thickened and granular, and adhesions between its folds lessen the capacity of the joint. Thus, if the advance of the tuberculous process has been retarded by efficient protection, it may involve but a small part of the former area of the joint when perforation occurs. An amount of tuberculous fluid, large enough to be diagnosticated as abscess, is present in about half the cases. This fluid usually finds an exit from the capsule into the tissues of the thigh, but occasionally it may pass through the acetabulum into the pelvic cavity. In rare instances the disease within the head of the femur may not enter the joint, but may make an opening in the neck outside the capsule, or it may even perforate the shaft of the femur. In such cases, the joint is, in most instances, finally involved unless the disease is removed by surgical means.

If the disease involves the neck of the bone it may so weaken its structure that the angle with the shaft is lessened, a form of coxa vara; or the head of the bone may be separated at the epiphyseal cartilage, with consequent upward displacement of the trochanter.

In by far the larger number of cases the joint is perforated and the head of the bone and the acetabulum are involved to a greater or less degree. In such instances the destructive effects of the disease are increased by the pressure and friction of the softened bones on one another, aggravated by the spasm of the surrounding muscles. Thus

FIG. 156.

Erosion of the head of the femur and of the upper border of the acetabulum. Formation of new bone (osteophytes) about the acetabulum.

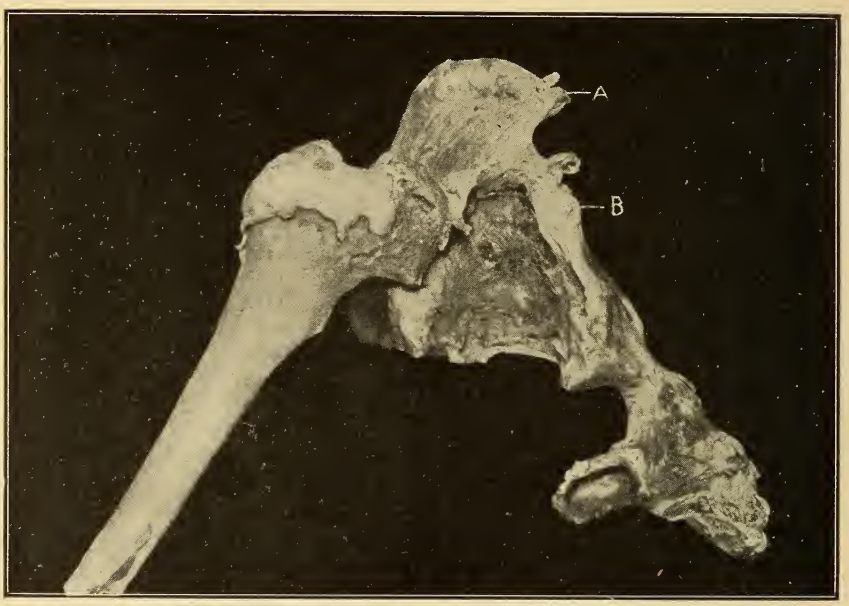
at the upper margin of the acetabulum and the inner and upper surface of the femur, there is greater loss of substance than elsewhere. (Fig. 156.)

The appearances in advanced cases of this type, as seen at operation or autopsy, may be summarized somewhat as follows: The head of the femur is deeply eroded, its cartilaginous covering has practically disappeared or is in part still adherent in necrotic shreds. It lies in sero-purulent fluid, surrounded by the gelatinous necrotic granulations that line the capsule and partly fill the enlarged acetabulum. In certain instances the pelvic bones may be diseased or the acetabulum may

be perforated (Fig. 158), or the shaft of the femur may be involved. Occasionally the disease may be from the first of an acute destructive type whose course is but little influenced by treatment, but in the majority of cases the progress of the disease, and its destructive effects, may be greatly modified by protection of the joint.

In the natural cure of the disease the focus, if it be small, may be absorbed and replaced by scar-like tissue; or the products of the disease may be separated from the healthy parts, and discharged by abscess formation. In other instances, a part in which the disease is still active may be inclosed within the newly formed tissue. Here the

FIG. 157.



Erosion of the head of the femur and of the upper margin of the acetabulum. A, anterior superior spine; B, anterior inferior spine.

process may remain quiescent or it may cause relapse, many years after the apparent cure of the disease. Or portions of necrosed bone, inclosed within the capsule, may prolong suppuration after the tuberculous disease has disappeared.

Etiology.—The etiology of tuberculous disease is discussed in Chapter V.

Relative Frequency.—Tuberculous disease of the hip joint is the most common and the most important of the affections of the joints, ranking second to Pott's disease. In a total of 7,845 cases of tuberculous disease treated in the out-patient department of the Hospital for Ruptured and Crippled during the past fifteen years, 1885–1899, 3,203 were Pott's disease; 2,230 were hip disease, while the remaining 2,408 cases included all the other joints.

Age.—Hip disease is essentially a disease of early childhood, although no age is exempt. In a series of 1,000 consecutive cases of hip disease tabulated for me by Dr. D. D. Ashley, assistant in the department, 88.1 per cent. of the patients were in the first decade of life, and 45.6 per cent. of these were from three to five years of age inclusive.

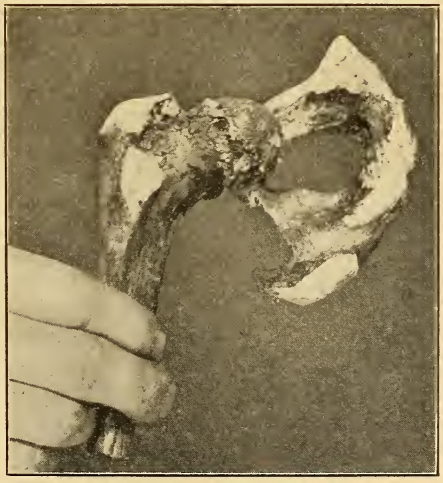
AGE AT INCIPIENCY.

Less than 1 year				9	Between 16 and 17 years				11
Between 1 and	2	years		39	"	17	"	18	" 4
" 2	"	3	"	107	"	18	"	19	" 5
" 3	"	4	"	155	"	19	"	20	" 0
" 4	"	5	"	158	"	20	"	21	" 3
" 5	"	6	"	139	"	21	"	22	" 3
" 6	"	7	"	90	"	22	"	23	" 1
" 7	"	8	"	51	"	23	"	24	" 2
" 8	"	9	"	51	"	24	"	25	" 3
" 9	"	10	"	40	"	25	"	26	" 1
" 10	"	11	"	33	"	26	"	27	" 1
" 11	"	12	"	19	"	27	"	28	" 1
" 12	"	13	"	18	"	28	"	29	" 1
" 13	"	14	"	23	"	30	"	33	" 4
" 14	"	15	"	7	"	33	"	36	" 1
" 15	"	16	"	8	Age not stated				12
									1,000

Sex.—Sex exercises but little influence although the disease is slightly more common among males than among females. In the 1,000 cases referred to, 553 (55.3 per cent.) were in males, 447 were in females.

In 3,307 cases treated at the same institution, 53 per cent. were in males.

FIG. 158.



Erosion of the head of the femur and destruction of the acetabulum.

Side Affected.—In disease of this as of other joints, the right is somewhat more often affected than the left. In the 1,000 cases 506 were on the right side, 483 were on the left and in 11 cases both joints were involved. In a larger number of cases treated in the department, 53 per cent. were of the right joint.

Symptoms. — Tuberculous disease of the hip joint is a chronic, insidious affection characterized by occasional exacerbations of more acute symptoms that are induced by over-strain or injury, by a more rapid advance of the destructive process, or by infection with pyogenic germs. In the early stage of the disease the joint is simply sensitive, and the symptoms vary according to the activity of the disease, which

may increase the tension within the bone; the susceptibility of the patient and the strain to which the weakened part is subjected. This sensitiveness is shown by the involuntary adaptation of the body to the weakness of the affected part, or as popularly expressed, the patient favors the leg.

The important symptoms of disease of the hip joint, in the sense of attracting attention to the affection, are **pain** and **limp**. Of the two, pain is much the less significant. Hip disease is by no means a painful disease, and although patients are often brought for treatment because of pain, it is very evident, on examination, that the disease must have existed long before the acute exacerbation called attention to its serious character. Even in cases in which the disease is far advanced in the destructive stage, one may be assured that the patient has never complained of pain.

Pain.—The characteristic pain of hip disease is "pain in the knee," just as the pain of Pott's disease is referred to the more important distribution of the nerves, whose filaments are irritated by the local process. The hip joint is supplied by the anterior crural, the sciatic and obturator nerves, but the pain is more often referred to the distribution of the last, thus to the inner side of the knee. Pain so persistently referred to the knee is misleading, and patients are often treated for obscure troubles in this joint long after an examination of the hip would have made the diagnosis evident.

Direct local pain and sensitiveness at the hip are unusual, unless the disease is acute in character or unless the tissues overlying the joint are implicated, as in abscess formation. The pain of hip disease is induced by sudden or unguarded movements, or by injury; therefore, in many instances, it is rather an occasional than a constant symptom.

Night Cry.—Pain at night is of importance, as it more often attracts attention than the occasional complaint of discomfort during the day. It is a common symptom when the disease is at all acute in character and it is often present when pain, during the period of activity, is apparently absent. It may be inferred, as an explanation of this symptom, that the joint gradually becomes more sensitive under the strain of use during the day, and that the relaxation of the voluntary and involuntary protection of the muscles allows sudden movements that excite spasmodic muscular contractions, which force the sensitive parts against one another. This causes a sharp cry. If the disease is acute, the child is usually awakened and is found holding the thigh with the hands or pressing upon the limb with the other foot, the evidence of pain being unmistakable. In the less sensitive conditions the patient does not wake after crying out, but simply moans or is restless for a time. If awakened it makes no complaint of pain and the cry is supposed to be caused by a "bad dream." This cry may be repeated several times, more often in the early part of the night.

Limp.—The limp is the most important of what may be classed as the preliminary signs of the disease. A limp is a change in the rhythm of the gait, a long step alternating with a shorter step. It is evident

that any interference with the function of the limb will cause this irregularity which can be concealed or diminished only by accommodating the normal member to its disabled fellow. Thus an inequality in length, or a limitation of motion in the joint, or distortion or weakness or pain, may cause an irregular gait, and several of these factors may be combined in the causation of the final disability of hip disease; but in the early stage the limp is due rather to sensitiveness than to any marked restriction of function. Thus the patient favors the joint by resting on the limb for a shorter time than on its fellow, and by bearing more weight upon the front of the foot than upon the heel. If the joint is more sensitive, the patient may bear practically all the weight upon the front of the foot, slight plantar flexion at the ankle being combined with slight flexion at the knee and hip; thus the jar of direct impact of the heel upon an extended leg, is avoided.

The limp is a very constant symptom of hip disease that is more or less noticeable according to the character of the disease; it is even subject to daily variations in the same patient, being, as a rule, more apparent in the morning or on changing from an attitude of rest, than during activity. In the early stage of the disease the limp may be even intermittent, although it is probable that in most instances some change from the normal gait might be detected by a practiced eye.

The other symptoms of disease of the hip joint are more properly physical signs that become evident on examination. These are: **Stiffness, distortion, change of contour of the hip, atrophy.**

Stiffness, due to reflex muscular spasm, is by far the most important sign of the disease. It is the instinctive expression of the inability of the joint to perform its full function and especially to allow the full range of motion which puts more strain upon the bones and the other components of the joint. It is the first and the last sign of disease; it probably precedes the limp and it remains long after pain has ceased to be a symptom, and until repair is complete.

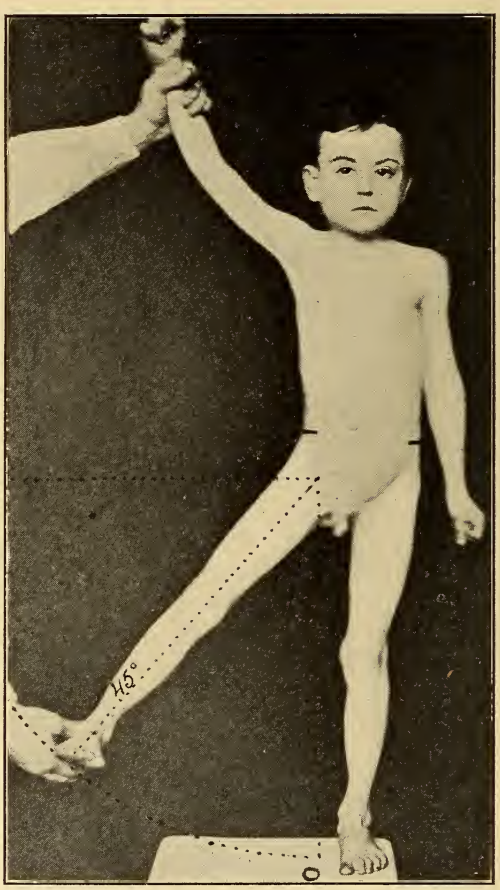
Reflex muscular spasm limits motion in *every direction* to a greater or less degree. In the early stage of the disease the motion, whether voluntary or passive, may be perfectly free throughout three-fourths of its normal range, but when the limit allowed by the muscular protection is reached, motion is checked by a peculiar elastic resistance. If an attempt is made to force the limb beyond the limit in any direction, the entire body follows the movement. The contraction of the surrounding muscles, including those of the trunk even, may be appreciated by the eye and by the hand, and the expression of the patient's face shows that the manipulation causes discomfort.

The degree of muscular spasm is in proportion to the sensitiveness of the joint rather than to the area of the destructive disease. Thus it may vary from day to day and even from hour to hour, and in the acute exacerbations of the disease motion may be for a time so absolutely restricted as to simulate anchylosis.

Reflex muscular spasm is an infallible sign of a sensitive joint; it is, of course, a symptom not confined to the tuberculous process, but

unless it be the direct effect of injury it shows the presence of disease, and if this disease be chronic and confined to a single joint it is, in childhood at least, almost always tuberculous in character. In the early stage of hip disease the restriction of motion is caused almost entirely by reflex muscular spasm, as is shown by the fact that when the patient is anæsthetized the range of motion becomes practically

FIG. 159.



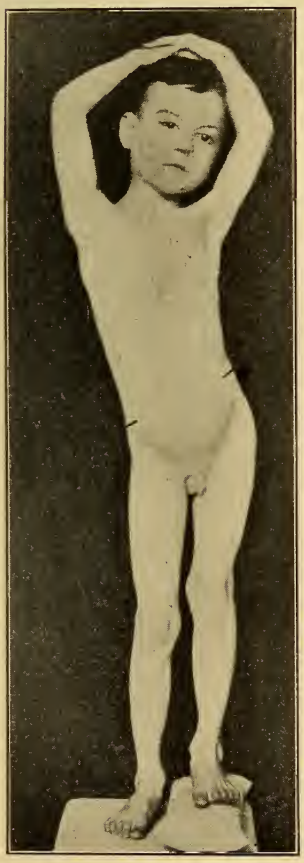
The stage of apparent lengthening. Fixed abduction of 45°. When the anterior superior spines are on the same plane, as in the illustration, the deformity is evident. (See Fig. 160.)

free. In the later stages, however, motion is still further restrained by adhesions and contractions, within and without the joint.

Distortion of the Limb.—Persistent reflex muscular spasm is always accompanied by a certain change in the attitude of the limb, slight flexion being the earliest indication of distortion in disease of the hip, as at every other joint. With this flexion there is usually abduction and slight outward rotation of the limb.

Flexion, Abduction and Outward Rotation — Apparent Lengthening.—This is the passive attitude or the attitude of rest in the normal condition, and in disease it shows the instinctive adaptation of the limb to a sensitive joint which is still capable of a certain amount of work. The limb, although still in use, is reduced in activity, the flexion lessens the direct jar and the abduction throws the limb aside,

Fig. 160.



Stage of apparent lengthening. When the distorted limb is brought to the median line the pelvis is so tilted that the abducted leg seems longer. (See Fig. 159.)

Fig. 161.

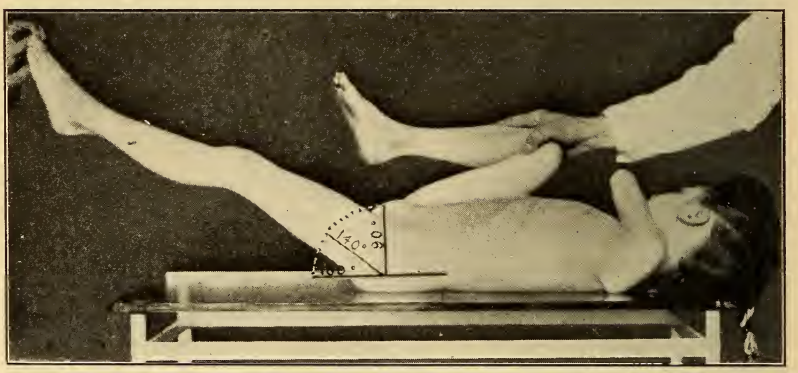
Right angle flexion in hip disease partly concealed by the compensatory lordosis, and by the flexion at the knee and ankle.

as it were, from the active attitude, making it a prop and adjunct of its fellow instead of an active aid in the propulsion of the body. This attitude is not voluntarily assumed by the patient ; it is involuntary and persistent. It is sometimes called the stage of apparent lengthening. The leg seems longer than its fellow because it is held away from the axis of the body, and in order to bring it into the middle line

and parallel to its fellow, the pelvis must be tilted downward on the diseased side, and upward on the other. The sound leg is drawn upward and the affected leg is lowered to a degree corresponding to the amount of abduction. (Fig. 160.) If, however, the anterior superior spines of the pelvis be placed upon the same plane, the distortion becomes evident. (Fig. 159.) Thus the deformity of the limb is concealed or compensated by a tilting of the pelvis which twists the lumbar spine into a lateral convexity, toward the lower side.

In the same manner the persistent flexion of the leg is concealed by a tilting of the pelvis forward, and by an increased hollowness or lordosis of the lumbar region. (Fig. 161.) Normally, in childhood at least, the lumbar spine and the popliteal surface of the knee should touch the table when the patient lies upon his back, but if the leg is fixed in flexion, the lumbar region must be arched and raised from the table when the leg rests upon it. Thus, in order to make the flexion appar-

FIG. 162.



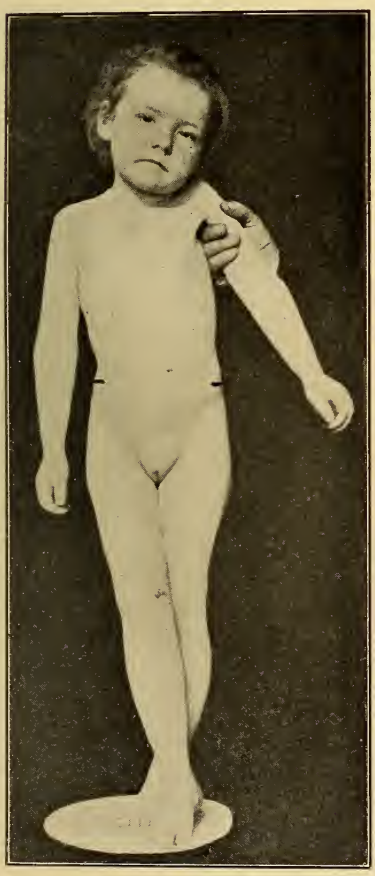
The degree of fixed flexion is shown when the lumbar spine is held in contact with the table by flexing the other thigh.

ent, the lumbar spine must be forced to touch the table, and this is possible only when the leg is raised to a degree corresponding to the deformity. (Fig. 162.) If the spine were rigid, as in advanced cases of rheumatoid arthritis, this compensation would be impossible, and if the patient were placed upon his back the leg could not be brought down to the table; or if both limbs were distorted, as is sometimes the case when both hip joints are diseased, the limbs would be widely separated or crossed over one another, according as the deformity were in abduction or adduction.

FLEXION, ADDUCTION AND INWARD ROTATION—THE STAGE OF APPARENT SHORTENING.—If the disease is of a more acute type, and if locomotion be permitted, the attitude usually changes to one of increased flexion, and adduction and inward rotation replace abduction and outward rotation. This attitude is an indication that the part is so disabled as to be of little use, and it is instinctively drawn

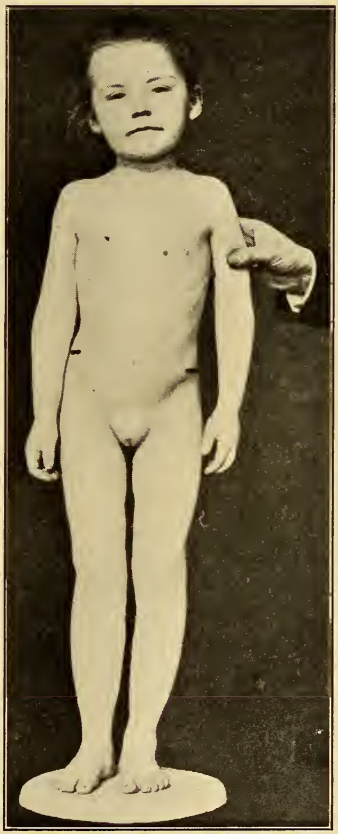
into a more protected attitude where it may be used as little as possible. If the patient be confined to the bed, or does not walk, as in hip disease in infancy, the attitude of abduction may persist, although the muscular spasm may be intense. Thus it would appear that locomotion has a distinct influence on the character of the distortion.

Fig. 163.



The stage of apparent shortening. The adduction of the right thigh is made evident by the involuntary crossing of the legs when the anterior superior spines are on the same plane.

Fig. 164.



The stage of apparent shortening. When the adducted limb is placed in the line of the body, the pelvis is tilted upward to a corresponding degree on the adducted side and downward on the other.

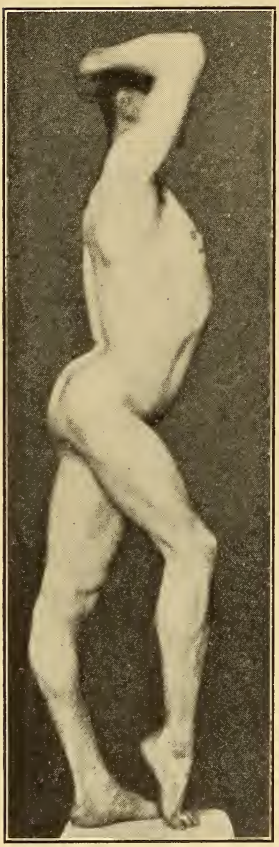
The patient has compensated for the apparent shortening by flexing the knee on the sound side. This does not appear in the photograph.

Flexion, adduction and inward rotation cause apparent or practical shortening ; for in order to bring the adducted limb to the middle line of the body and parallel with its fellow, the pelvis must be tilted upward on the affected side and downward on the other, the lumbar spine bending with a convexity toward the lower side. (Figs. 164,

167.) If the level of the pelvis be restored, the adducted limb will be crossed over its fellow, and the deformity is made evident. (Fig. 163.)

As has been stated the attitude of flexion, adduction and inward rotation, if it appears early in the disease, is usually an indication of acute and disabling pain and of corresponding intensity of muscular spasm. But in most instances it is associated with the later and destructive stage of the disease and it by no means indicates that the preceding symptoms have been more than ordinarily acute. In fact it is the attitude characteristic of a so-called "natural cure" (Fig. 165) when mechanical treatment has not been employed. It more often accompanies the later stage of the disease, because its causes are in great degree mechanical.

Fig. 165.



The final effect of hip disease when untreated. The natural cure, with flexion and adduction.

The mechanics of the distortion will be made clearer if it be compared to the deformity symptomatic of dorsal dislocation of the hip. In this displacement the femur, forced upward and backward upon the pelvis, is fixed in an attitude of extreme flexion, adduction and inward rotation. Each of the destructive changes of hip disease, the enlargement of the acetabulum, the depression of the neck of the femur, the erosion of the head of the bone, allows an elevation of the femur upon the pelvis or an approximation to a dorsal displacement. (Fig. 169.) If this displacement occur suddenly, as in certain cases of acute disease attended by effusion and rupture of the capsule, the limb immediately assumes an attitude typical of dorsal dislocation; but in the ordinary form of disease the changes are very gradual, the pelvis and the femur, being in most instances undeveloped, more easily accommodate themselves to the changed conditions so that the actual distortion is less marked than in a similar subluxation of traumatic origin in the adult, but the simile will serve to illustrate the mechanical causes of distortion, and why such deformity may recur after correction, even though the disease has entirely disappeared.

Outward rotation of the limb is usually associated with abduction, and inward rotation with adduction, but in certain instances outward rotation may be combined with adduction and vice versa. These irregular attitudes are more often observed in cases that have received mechanical or operative treatment.

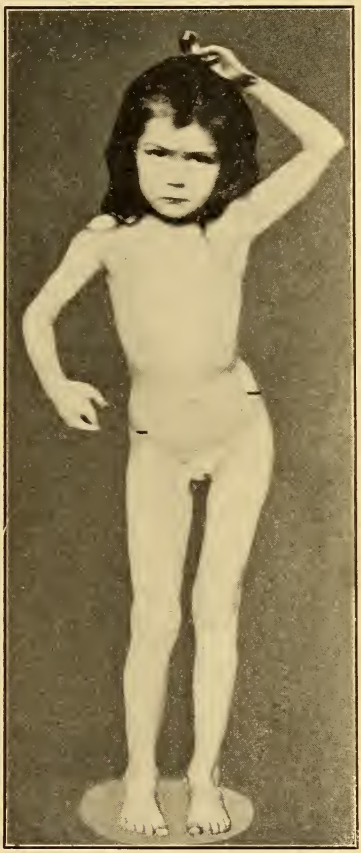
As has been stated, the distortions of the early stage of hip disease

are caused almost entirely by muscular contraction which relaxes under the influence of an anæsthetic, but after a time the attitude is still further assured by accommodative changes in the muscles and fasciæ, and by contractions and adhesions about the capsule. Thus an attitude which was originally a symptom may persist after the cure of the disease.

Fig. 166.

Untreated hip disease. Flexion deformity to nearly a right angle with the body. Trochanter two inches above Nélaton's line. Compensatory lordosis.

Fig. 167.



Stage of apparent shortening. The left limb is adducted 35°, making an apparent shortening measured from the umbilicus of more than two inches. In order to reduce the obliquity of the pelvis, the adducted leg must be crossed over its fellow. (See Fig. 163.) The apparent shortening is compensated by the flexion at the knee on the sound side. This is not made clear in the photograph.

In conclusion it may be stated that flexion is practically an invariable symptom in hip disease because complete extension, the attitude that puts most strain upon the joint, is first restricted. Flexion is, in the milder or in the earlier class of cases, usually combined with abduction and outward rotation, the attitude of inactivity. Increased

flexion, accompanied by adduction and inward rotation in the early stage, is an indication of a more acute phase of the disease, but if the attitude is retained for a time it becomes fixed by accommodative changes in the tissues so that this distortion is not unusual in cases in which the damage to the joint may be very slight, as for example, when it follows rheumatism or some form of infectious arthritis. But in most instances the attitude is indicative of more advanced disease and of serious changes within the joint.

Changes in the Contour of the Hip.—In the early stage of the disease the changes in contour are caused in great part by the attitude of the limb. If, as is usual, it is flexed, abducted and rotated outward, the buttock appears somewhat flatter and broader than its fellow. The gluteo-femoral fold is lower because of the tilting downward of the pelvis and it is shallower because of the flexion. If the thigh is adducted, the gluteal fold will be elevated and shortened. On the anterior aspect, the inguino-femoral fold is deepened and lengthened by flexion and adduction, while abduction makes it less noticeable. Hoffman has called attention to the fact that the genitals and the intergluteal fold point toward the adducted and away from the abducted thigh. Adduction makes the trochanter more prominent, and abduction makes it less prominent.

To these primary changes in the appearances must be added the effect of atrophy or of infiltration and swelling, due directly to the disease. A certain amount of swelling is often apparent in the inguino-femoral region, and infiltration of the deeper tissues is sometimes evident on palpation. In such cases there is usually a certain sensitiveness to deep pressure, behind or in front of the trochanter. Palpable or evident abscess is unusual in the early stage of the disease.

Atrophy.—Atrophy is an important sign of joint disease. It is often appreciable to the eye and to the hand, and it is always demonstrable by measurement. It is an important symptom because, if well marked, it shows that the disease must have existed for some time, whatever may be the statement of the patient's relatives.

The atrophy affects the muscles of the entire limb, although it is somewhat more marked in the muscles of the thigh than in the calf. In the ordinary case of hip disease in childhood, when the patient is first brought for treatment, it averages from one half to one inch in the thigh and somewhat less in the calf.

The Causes of Atrophy.—The causes of the atrophy secondary to joint disease have been the subject of much discussion. As it is associated with an increase of the reflex excitability of the muscles, and as it often progresses with great rapidity, the prevailing theory has been that of Vulpian and Charcot, that it is of nervous or reflex origin. According to this hypothesis the atrophy is the result of a change in the trophic centers of the spinal cord, "an inertia," due to irritation of the articular filaments of the nerves.

Another theory has been advanced by Saborin. As branches of the same nerves are distributed to the joint and to the surrounding mus-

cles, he suggests that the atrophy may be caused by a direct implication of the nerves whose filaments are involved in the disease of the joint, a form of molecular neuritis.

Admitting that the secondary causes of atrophy are somewhat obscure, one cause, and by far the most important, is very evident. This is physiological disuse, and thus diminished nutrition of the limb which has become incompetent to carry out its full function. Atrophy is a constant symptom of simple disuse in the absence of disease. If a bone has been broken, atrophy of the surrounding muscles is observed. If anchylosis of a joint occur from any cause, whether it be from injury or disease, atrophy of the muscles, whose function has been abolished, follows. Even the atrophy caused by disease of the hip joint is greater when the limb has been fixed in apparatus, than when none has been applied, although the treatment has allayed the pain and has checked the progress of the disease. This point is illustrated by the observations of Brackett[1] who contrasted the atrophy of hip disease in two groups of patients, in one of which motion had been permitted, while in the other fixation, as complete as possible, had been employed. In the first group the average of atrophy was but 1 per cent. of the volume of the thigh and .89 per cent. of that of the leg, as contrasted with 23 per cent. and 17 per cent. in the second class.

It has been stated in objection to this theory that atrophy is observed even though the patient be confined to the bed, but under these conditions there would be relative disuse of a limb if motion caused pain or discomfort. Meanwhile a lesser atrophy might be demonstrated in the sound limb that had been deprived of its normal stimulus, just as relative hypertrophy of a limb which has to perform double function, is often observed.

The atrophy caused by physiological disuse and diminished nutrition affects all the components of the limb. The skin becomes thinner, the muscles lose in volume, the contractile substance is replaced in part by fat and by fibrous tissue, and the medullary canals of the bones enlarge at the expense of the cortical substance.

In childhood, the period of rapid development, disuse often causes a retardation in growth of the entire extremity. This may be apparent in the foot when it is placed by the side of its fellow, while the diminished growth in length of the limb, may be demonstrated by measurement. Brackett, in a series of cases, found this shortening to be distributed as follows: average loss of the femur, 6.6 per cent. and of the tibia 5.4 per cent. of the normal length.

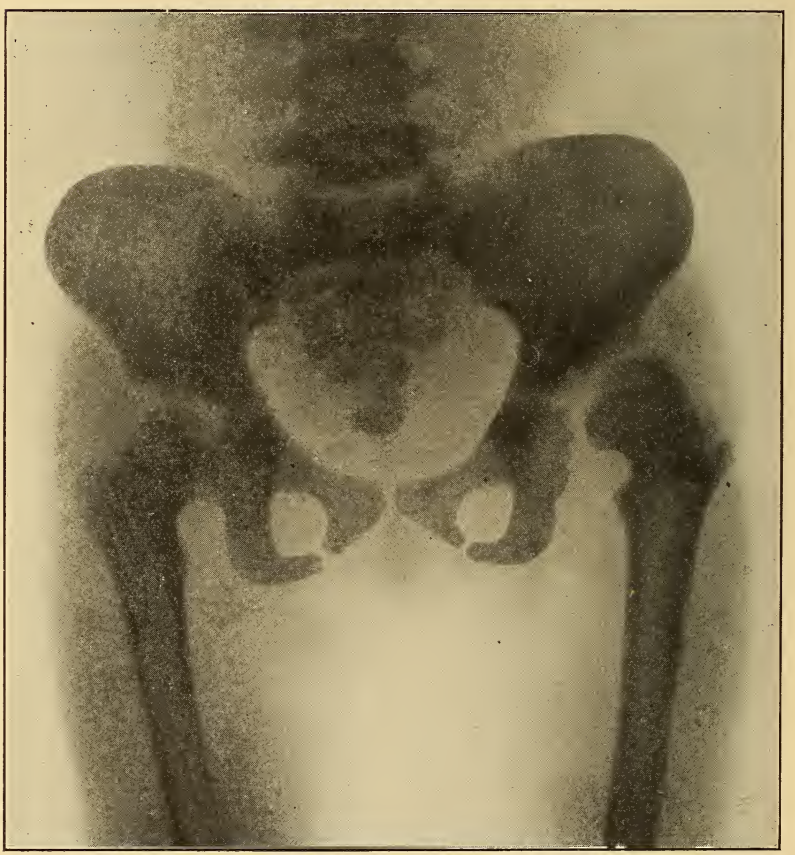
This atrophy, the direct result of the disease and of the long continued disuse during the period of repair, becomes less noticeable after function is resumed. The degree of final inequality depending upon the severity of the disease, the duration of the treatment and upon the impairment of function. But even when free motion in the joint is retained, a certain amount of atrophy always persists and the loss in

[1] Trans. Am. Orth. Ass'n, Vol. IV.

growth is never replaced. If motion is completely abolished the muscles about the joint lose in bulk in proportion to the disuse of their normal function; whereas the bones of the limb which are still used to support the weight retain to a greater degree their normal size and length. Combined with the atrophy of the weak limb there is a relative hypertrophy of the sound leg which is forced to assume more than its share of work.

Actual Shortening.—Actual shortening of the limb is a common

Fig. 168.



Early stage of disease of the left hip joint (to the right in the picture) of the synovial type, showing irregularity in the shape of the acetabulum.

effect of hip disease, but it can hardly be called a symptom for it is not present in the early stage of the disease.

The causes of actual shortening may be classified as:

1. Disuse of the limb.
2. The effect of the disease upon the epiphysis of the head of the femur.

3. The more general destructive effects of the disease that cause upward displacement of the femur.

(*a*) Erosion of the head.

(*b*) Erosion of the acetabulum.

(*c*) Depression of the neck of the femur.

Disuse, throughout a long period of treatment, may cause a certain amount of shortening of the entire limb. To this the shortening of the

FIG. 169.

Advanced disease showing wandering of the acetabulum and the obliquity of the pelvis due to adduction. Actual shortening 1 inch, apparent shortening 3 inches.

bones of the leg and of the foot may be attributed in great part. If the epiphysis of the head of the femur is destroyed in whole or in part or if the disease hastens its union with the bone, a certain loss of growth must follow. This is of course slight in degree because this epiphysis is relatively unimportant compared with that at the lower extremity of the bone. From these two causes, the atrophy of disuse and the effect of the disease upon the epiphysis, relative shortening of the limb may increase after the disease is cured.

Erosion of the head of the femur and of the upper border of the acetabulum are usually combined in those cases in which the shortening is in part dependent on upward displacement of the trochanter. (Fig. 156.) Depression of the neck of the femur to an appreciable degree is less common. Elevation of the trochanter, due to one or more of these causes, a form of subluxation, is very common, particularly so in those cases in which the protective treatment has been inefficient. Greater displacement follows fracture of the weakened neck and complete absorption of the head, and occasionally a fairly normal femur may be actually dislocated as a result of sudden effusion into the joint with rupture of the capsule, a form of pathological dislocation.

Actual Lengthening of the limb as the result of disease is occasionally observed, caused it may be inferred, by stimulation of the growth of the epiphysis of the head; but the most extreme instances are those in which the upper portion of the shaft of the femur is involved, the lengthening being the effect of an irritative hypertrophy.

Retardation of Growth.—As has been stated, all the components of the limb are affected by the retardation of the growth. Brackett's observations on this point have been mentioned, and the following table, showing the relative measures of the bones in cases under treatment by Döllinger[1] of Budapesth, presents the subject in a convenient form:

No. of case.	Age at inception.		Duration of disease.		Length of femur in cm.		Difference.	Length in tibia in cm.		Difference
	Years.	Months.	Years.	Months.	Diseased.	Normal.		Diseased.	Normal.	
1	8	6	—	6	28½	28	+½	24	24	—
2	3	4	—	8	23	24	1	19	19	—
3	2	10	1	8	24	24	—	19.5	19.5	—
4	5	—	2	—	29	30	1	23.5	23.5	—
5	6	—	2	—	27	28	1	23	23	—
6	7	—	2	—	32	33	1	27	27	—
7	9	—	2	—	37	37	—	30	30	—
8	1	—	4	—	22	24	2	18.5	19	0.5
9	13	—	4	—	38	41	3	34	34	—
10	4	6	5	—	32	34	2	27	27	—
11	—	2½	6	—	26	27	1	21½	23	1
12	13	—	7	—	38	40	2	33	33	—
13	2	—	8	—	35	36	1	28	28	—
14	6	—	8	—	38	38	—	31	32	—
15	11	—	8	—	40	44	4	34	34	—
16	5	—	10	—	45	46	1	—	—	—
17	5	—	11	—	41	44	3	31	37	6
18	6	—	14	—	44	48	4	36	39.5	3.5
19	2	—	18	—	36	46	10	38	38	—
20	2	—	28	—	44½	45	½	37.5	37.5	—

A similar investigation of thirty-three cases under treatment at the Hospital for Ruptured and Crippled, New York, has been made recently by Dr. Henry Ling Taylor. In these cases the shortening of the bones was found to be more generally distributed than in those reported by Döllinger, as is illustrated by the following table:

[1] Zeits. für Orth. Chir., Bd. 1, 1892.

Case.	Sex.	Age.	Side.	Duration of disease, years.	Duration of treatm., years.	Abscess.	Shortening in inches.				
							Entire limb.	Femur.	Tibia.	Foot.	Patella.
1	F.	3½	L.	1	1	No	½	—	½	⅜	⅛
2	M.	7	R.	1½	1	No	¼	x	¼	⅜	⅛
3	M.	5	L.	2	1	No	⅛	¼	¼	⅛	⅛
4	M.	5	R.	2	1½	No	¾	⅛	⅜	⅜	¼
5	M.	6½	L.	2½	1½	Yes	¾	¼	⅜	⅜	¼
6	F.	4½	L.	3	3	No	—	—	—	—	¼
7	F.	6½	R.	3	—	No	½	—	¼	—	—
8	M.	6	R.	3	2½	No	⅜	¼	¼	½	⅜
9	F.	13	L.	3½	2	No	¾	—	⅝	⅛	⅛
10	F.	7	L.	3½	3½	No	⅜	½	¾	⅞	¼
11	M.	7	R.	3½	3½	Yes	1	¼	¾	¾	⅜
12	F.	11	R.	3½	1½	No	¾	¼	⅝	¼	⅛
13	F.	9	L.	3½	3½	No	¼	—	½	½	⅛
Average		7		2½	2		¾	⅛	½	¼	⅛
14	M.	7	R.	4	4	No	1	¾	¼	¾	½
15	F.	8½	R.	4	4	No	1	¼	½	¼	⅝
16	F.	12	R.	5	4	Yes	3¼	½	1¼	⅝	x
17	F.	11	R.	5½	4	Yes	2¼	1	½	¼	½
18	F.	13	L.	6	3	No	2	½	1⅛	⅜	¼
19	F.	12	L.	6	4	No	⅞	¾	¾	⅜	⅜
20	F.	10	L.	6½	4	No	1¼	¼	¼	—	¼
21	M.	14	L.	7	x	Yes	2½	x	¾	¾	¼
22	F.	15	R.	7	5	No	2¼	x	1	½	x
23	M.	9½	R.	7	½	Yes	1¼	—	½	¼	x
Average		11		5½	3½		1¾	½	¾	½	⅜
24	F.	13	R.	8	7	Yes	2¼	¼	1½	1	¼
25	M.	15	R.	9	6	Yes	4½	2	1¾	x	x
26	M.	10½	R.	9	x	No	1½	½	⅛	¼	½
27	F.	18	R.	9	7	No	2¾	x	1	½	¼
28	M.	18	R.	11	10	Yes	2	½	1	⅝	x
29	F.	15	L.	11	7	Yes	3	¼	⅞	¼	⅜
30	F.	15	R.	11	5	Yes	1	¼	¼	½	¼
31	F.	15	R.	11½	9½	Yes	3	¾	¾	½	½
32	F.	16	L.	14	1	No	1½	¾	¾	⅛	½
33	F.	21	L.	17	6	Yes	5½	2½	2½	¾	¼
Average		15		11	6		2¾	⅞	1	½	⅜

— Measurements equal.
x Measurements not taken.
Measurements of the femur from the apex of the great trochanter to the knee joint. Patella measured transversely. The cases are grouped according to the duration of disease and the averages are given separately for each group.

Dr. Taylor measured also ten cases of unilateral poliomyelitis, in patients of an average age of thirteen years with an average duration of disability of ten years. The average shortening in these cases was one and three-fourths inches and in no case was it greater than two and one-half inches. It will be noted that the retardation of growth in this group corresponds closely with that of the third group of cases of hip disease, in which the disability was of about the same duration.

Taylor concludes that the retardation of growth from unilateral hip disease in childhood is dependent in great degree upon the duration of the disability and upon the corresponding restraint of function. Similar observations on fifty cases of hip disease have been recorded by Hibbs.[1] In eleven of these cases the femur was found to be slightly longer on the diseased side.

General Symptoms of the Disease. **Debility.**—If the disease be sufficiently painful to cause loss of sleep, and to affect the appetite, pallor and loss of flesh and strength may be expected. It must be borne in mind, however, that the patient may have been "delicate" long before the local tuberculous disease was acquired. At all events, from the diagnostic standpoint at least, the local disease has no characteristic influence upon the general condition and the appearance of perfect health is not at all unusual among patients with hip disease.

Fever.—It is probable that a slight elevation of temperature might be detected in a large proportion of the patients, and in such cases actual appreciable fever often follows over-exertion or injury. Fever, as a symptom of infected abscess in the later stage of the disease, is of course of importance, but in the early stages of the disease the record of the temperature would be of but little diagnostic value.

The History and the Method of Examination.—In considering the differential diagnosis of tuberculous disease of the hip joint one should keep its characteristics in mind. It is a chronic disease, in that the symptoms may have been present for weeks or months or even years before the patient is brought for treatment. It is a disease confined to a single joint, thus differing from rheumatism and similar affections in which several joints are involved. It does not get well; thus it may be differentiated from injury and from the minor affections that simulate some of its symptoms. It causes a limp. It is accompanied by reflex muscular spasm, usually by a certain amount of deformity and by general atrophy of the muscles of the limb.

The importance of the inheritance and of the personal history of the patient has already been mentioned in the consideration of Pott's disease. In recording the history in this, as in all other chronic diseases of childhood, one attempts to ascertain the approximate duration of the pathological process rather than the duration of the more acute symptoms for which the patient has been brought for treatment. One asks, therefore, when the child was last perfectly well, and, bearing in mind the remission of symptoms, one asks if limp or pain had been noticed at any time before the more acute symptoms. In the history there is almost invariably mention of a fall, and one must ascertain whether the fall had any influence in the causation of the symptoms, remembering that the weakness and interference with function due to joint disease more often cause falls than falls cause joint disease.

Physical Examination.—One begins the physical examination by the observation of the general condition of the patient and notes the attitudes and the character of the limp. The patient's clothing is then

[1] N. Y. Med. Jour., Dec. 16, 1899.

entirely removed and one may observe the contour of the part and the general influence of the affection upon the mechanism of the body. The patient is then placed on his back upon a table, with the legs parallel to one another, so that their relative length and size may be observed. If the pelvis is level, when the limbs are parallel, there can be no persistent abduction or adduction, for when the two anterior superior spines are on the same plane, such distortion is always evident. If the lumbar spine and the popliteal surfaces of the knees rest on the table simultaneously, it shows too that persistent flexion is absent. One next tests the functions of the hip joints, always beginning with the sound side for the purpose of comparison and in order that the patient may become accustomed to the manipulation, before the one suspected of disease is tested. Muscular spasm, due to disease within a joint, limits motion in every direction, thus differing from various conditions outside the joint that may limit its motion in one or more, but not in all directions.

One compares the flexion, abduction, adduction and rotation of the limbs while the child lies upon its back; it is then turned upon its face to test for extension, by holding the pelvis flat upon the table with one hand, while the thigh is gently elevated with the other. (Fig. 16.) The normal range of extension, in childhood, is at least ten degrees backward from the line of the body, and limitation of this range is the earliest sign of approaching deformity of hip disease. It may precede the restriction of the extremes of motion in other directions, although this is unusual, and if this motion is unrestricted, disease of the joint may be, practically speaking, excluded. The character of the reflex spasm that limits motion, and the indications of discomfort when the limit has been reached have been described.

Measurements.—The measurements of the limbs are then made. One first ascertains the actual length of the limbs by measuring from the anterior superior spines of the pelvis to the extremities of the internal malleoli, actual shortening being of course absent in the early stage of the disease. The second measurement is from the umbilicus to show the amount of apparent shortening or lengthening that may be present if the limb is distorted. The actual length of the legs, as measured from the anterior superior spines, is not changed by tilting of the pelvis, but as the umbilicus is in the middle line of the body above the pelvis, measurement from this point simply shows the actual distance to the malleoli. Adduction causes an obliquity of the pelvis, consequently the malleolus on the affected side is drawn upward or nearer to the umbilicus, while the other is carried downward to a corresponding distance. (Fig. 167.) If, then, the measurements from the umbilicus to the malleoli do not correspond relatively with those from the anterior superior spines, when the limbs are parallel and in the median line, it shows distortion; adduction, if the limb is relatively shorter, abduction, if it is relatively longer than is shown by the measurement from the anterior superior spine. It has been stated that the measurement from the anterior superior spine is not changed by distortion.

It is, however, shortened slightly by outward rotation and more appreciably by abduction and also by flexion. Flexion on one side causes a tilting forward of the pelvis that affects the measurements on both sides, thus it is customary, if the flexion is considerable, to raise the sound leg to the line of its fellow in making the comparative measurements, stating in the record that the limbs have been measured at the angle of the deformity.

Method of Estimating the Degree of Distortion of the Limb.—As has been stated, when the pelvis is level, distortion of the limb is apparent, and the degree of distortion can be measured by the goniometer. (Fig. 159.) But it may be more easily ascertained by "Lovett's table."[1] This method is described by its author as follows :

Table I.

Distance Between Anterior Superior Spines in Inches.

Difference in inches between Real and Apparent Shortening.	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13
¼	5°	4°	4°	3°	3°	2°	2°	2°	2°	2°	2°	2°	2°	1°	1°	1°	1°	1°
½	10	8	7	6	5	5	4	4	4	4	4	4	4	3	3	3	3	2
¾	14	12	11	10	8	8	7	7	6	6	5	5	5	4	4	4	3	3
1	19	17	14	13	11	10	9	9	8	7	7	7	6	6	6	5	5	4
1¼	25	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6
1½	30	25	22	19	17	15	14	13	12	12	11	10	10	9	9	8	7	7
1¾	36	30	26	23	20	18	17	15	14	13	13	12	11	10	10	9	8	8
2	42	35	30	26	23	21	19	18	16	15	14	14	13	12	12	10	10	9
2¼	...	40	34	30	26	24	21	20	19	17	16	15	14	14	13	12	11	10
2½	...	...	39	34	29	27	24	22	21	19	18	17	16	15	14	13	12	11
2¾	...	...	...	38	32	29	27	25	23	21	20	19	18	17	16	14	13	12
3	...	...	...	42	35	32	29	27	25	23	22	21	19	18	18	16	14	13
3¼	...	...	...	...	39	36	32	30	27	26	25	22	21	20	19	17	15	14
3½	...	...	...	...	...	40	35	33	30	28	26	24	23	22	21	19	17	16
3¾	...	...	...	...	...	...	38	35	32	30	28	26	25	23	22	20	18	17
4	...	...	...	...	...	...	42	38	35	32	30	28	26	25	23	21	19	18

"To measure by this method, the patient is made to lie straight, with the legs parallel. Real shortening is measured with the ordinary tape measure, and apparent shortening is obtained in the same way. It may be repeated that real or bony shortening is measured from the anterior superior iliac spines to each malleolus, and that practical shortening is found by a measurement taken from the umbilicus to each malleolus. The difference in inches between the two kinds of shortening is seen at a glance. The only additional measurement

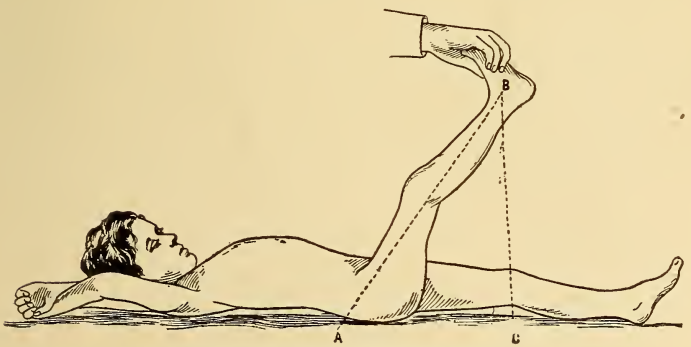
[1] R. W. Lovett, Boston Med. and Surg. Jour., March 8, 1888.

necessary is the distance between the anterior superior spines, which is taken with the tape. Turning now to the table, if the line which represents the amount of difference in inches between the real and apparent shortening is followed until it intersects the line which represents the pelvic breadth, the angle of deformity will be found in degrees, where they meet. *If the practical shortening is greater than the real shortening, the diseased leg is adducted; if less than real shortening, it is abducted.* Take an example: Length (from anterior superior spine) of right leg, 23; left leg, 22½; length (from umbilicus) of right leg, 25; left leg, 23; real shortening, ½ inch, apparent shortening 2 inches; difference between real and practical shortening, 1½ inches; pelvic measurement, 7 inches. If we follow the line for 1½ inches until it intersects the line for pelvic breadth of 7 inches, we find 12° to be the angular deformity, as the practical shortening is greater than the real, it is 12° of adduction of the left leg. If apparent lengthening is present its amount should be added to the amount of actual shortening."

If flexion be present the degree may be ascertained by raising the flexed leg until the lumbar spine touches the table, when the angle formed by the leg with the body may be measured with the goniometer (Fig. 162), or its degree may be ascertained by Kingsley's table.

"The patient lies upon a table flat on his back and the surgeon flexes the diseased leg, raising it by the foot until the lumbar vertebræ touch the table, showing that the pelvis is in the correct position. The leg is then held for a minute at that angle, the knee being extended, while the surgeon measures off two feet on the outside of the leg with a tape

FIG. 170.



Kingsley's method of estimating flexion.

measure, one end of which is held on the table (so that the tape measure follows the line of the leg) (*AB*). From this point on the leg (*B*) where the two feet reaches by the tape measure one measures perpendicularly to the table (*BC*), and the number of inches in the line *BC* can be read as degrees of flexion of the thigh, by consulting Table II. For instance, if the distance between the point on the leg and the table is 12½ inches it represents 31° of flexion deformity of the thigh.

TABLE II.[1]

In.	Deg.	In.	Deg.	In.	Deg.	In.	Deg.
0.5	1	6.5	16	12.5	31	18.5	50
1.0	2	7.0	17	13.0	33	19.0	52
1.5	3	7.5	19	13.5	34	19.5	54
2.0	4	8.0	20	14.0	36	20.0	56
2.5	6	8.5	21	14.5	37	20.5	58
3.0	7	9.0	22	15.0	39	21.0	60
3.5	9	9.5	24	15.5	40	21.5	63
4.0	10	10.0	25	16.0	42	22.0	67
4.5	11	10.5	27	16.5	43	22.5	70
5.0	12	11.0	28	17.0	45	23.0	75
5.5	14	11.5	29	17.5	47	23.5	80
6.0	15	12.0	30	18.0	48	24.0	90

"If the leg is so short that it is impracticable to measure off twenty-four inches, one can measure twelve inches; ascertain from here the distance to the surface on which the patient is lying in a perpendicular line in the same way, then doubling this distance and looking in the table as before the amount of flexion is found."

ATROPHY.—The circumference of the thighs, the knees and the calves is then measured at corresponding points, to test for atrophy or for other irregularities that may require explanation. The atrophy of joint disease affects the entire limb, and is an unfailing symptom except in the earliest stage of the disease. It might be concealed in the thigh by a deep abscess, but it would still appear in the calf.

Local Signs of Disease.—The hip joint is so concealed by the overlying tissues that the local sensitiveness and swelling which usually accompany similar disease at the knee and ankle, are often absent. Firm pressure, before or behind the trochanter, or over the head of the femur, usually causes some discomfort, however. In many instances a peculiar resistance of the deeper parts, caused by infiltration of the tissues that cover the joint, is evident on palpation; and swelling about the joint and thigh, caused by effusion or by deep abscess, is not unusual when patients are first brought for treatment. Sensitiveness of the skin, and local elevation of the temperature may be present if the disease is acute, particularly if an abscess is on the point of breaking through the skin.

It must be evident that the diagnosis of tuberculous disease of the hip, except perhaps in the stage of inception, is in most instances evident on a systematic examination, such as has been outlined; and it is probable that errors are due rather to a neglect of such examination than to any particular obscurity that the ordinary case may offer.

Diagnosis. **Local Irritation.**—Strains of the muscles of the thigh, enlarged glands in the groin, irritation or disease of the genitals may, in infancy or early childhood, cause persistent flexion of the thigh and pain on motion. Simple muscular strains quickly recover, while the inflamed glands, and other causes of local irritation, are usually apparent on inspection.

[1] G. L. Kingsley: Bost. Med. and Surg. Jour., July 5, 1888.

"Growing Pains."—So-called growing pain is probably due in many instances to strain of the muscles or to injury about the hip; in other cases it may be explained by rheumatism.

Local Injury.—It would appear that injury, often of a trivial character, may cause congestion in the neighborhood of the epiphyseal cartilage of the head of the femur and that injury of this character in delicate children may be the predisposing cause of tuberculous disease. Such a sensitive condition causes a limp, pain or discomfort on overuse and a certain amount of restriction of motion. These symptoms may last a few days or a few weeks; they may disappear and recur from time to time and they can only be distinguished from those of incipient disease by continued observation.

Synovitis.—In certain cases of injury synovial effusion may be present, although this is unusual.

In the cases in which the functional disturbance is caused by local irritation or by slight strain the symptoms are of sudden onset and are evidently of trivial importance, but if there is any doubt as to the diagnosis, the hip should be bandaged and the patient should remain in bed or at rest, until the complete subsidence of the symptoms or their persistence, makes the diagnosis clear.

Anterior Poliomyelitis.—Occasionally anterior poliomyelitis may be accompanied by pain on motion in the affected limb, before paralysis is apparent; but in a few days, at most, the diagnosis is evident.

Rheumatism.—Rheumatism is usually of sudden onset. It is almost always migratory in character and it is accompanied by fever. If it were confined to a single joint, as is sometimes the case in young children, and if the history were obscure, the diagnosis might be uncertain for a time. In such cases appropriate remedies should, of course, be employed.

Scurvy.—This is also an affection whose symptoms are general in character. It is, therefore, more likely to be confounded with rheumatism than with a local disease. In rare instances one joint only appears to be involved, but this is, as a rule, the knee rather than the hip. Pain on motion of the limbs, in an infant artificially fed, always suggests scurvy.

Infectious Arthritis.—Mild forms of infectious arthritis may follow scarlet fever, diphtheria, pneumonia and, in a more severe and destructive form of typhoid fever. As a rule however several joints are involved and although the affection might be mistaken for rheumatism it could hardly be confounded with local tuberculous disease.

Acute Epiphysitis.—Infectious arthritis or epiphysitis of the hip joint is not uncommon in early infancy. It is of sudden onset, accompanied by high fever and by constitutional disturbance. These symptoms together with the local heat and swelling, caused by the rapid formation of pus, show the character of the affection and indicate the necessity for prompt surgical intervention.

Extra-articular Disease.—Disease in the neighborhood of the joint, as of the trochanter, or of the tuberosity of the ischium, may cause a

limp and pain, but in most instances the local sensitiveness and local swelling indicate the seat of the disease, while motion of the joint is limited only in the directions that cause tension on the sensitive parts.

Chronic Rheumatoid Arthritis. Osteo-arthritis of the Hip.—Rheumatoid arthritis, when confined to the hip joint, may be mistaken for tuberculous disease and at times the diagnosis may be obscure. This is, however, a disease of adult life and it is in most instances accompanied by other evidences of a general affection.

Pott's Disease.—Disease of the lumbar region of the spine before the stage of deformity, when the pain is referred to the lower extremities, and in which unilateral psoas contraction causes a limp, is almost always mistaken for hip disease although the distinction between them is very clear. Psoas contraction limits only extension; all the other movements of the limb are free and unrestrained. The muscular spasm, of which the psoas contraction is a part, is a spasm of the muscles of the spine about the seat of disease, as is evident on examination. Other causes of psoas contraction have been mentioned in the consideration of Pott's disease. In exceptional cases active disease of the lower region of the spine in young children may set up spasm of the muscles about the hip, and vice versa, so that it may be impossible to decide at the first examination whether the irritation is in the hip or in the spine or in both.

Sacro-iliac Disease.—Disease of the sacro-iliac junction is very uncommon in childhood. The symptoms and the attitude resemble sciatica rather than hip disease. There is local pain at the seat of disease upon lateral pressure on the pelvis, and if the pelvis be fixed, the motion at the hip joint will be found to be free and painless.

Disease of the Bursæ about the Joint.—Inflammation of the bursæ about the hip may cause local swelling and sensitiveness, a limp and limitation of motion in certain directions, but the characteristic muscular spasm of hip disease is absent. Ilio-psoas bursitis forms a fluctuating swelling on the inner aspect of the thigh, gluteal bursitis, a localized swelling of the buttock.

Coxa Vara.—Coxa vara, or depression of the neck of the femur, is a simple deformity in which disease is absent. It causes a limp and more or less discomfort, but the character of the deformity, shown by the actual shortening and by the elevation and prominence of the trochanter distinguishes it from hip disease in which these are late symptoms. In coxa vara there is unequal limitation of motion, abduction, flexion and inward rotation being somewhat restricted while extension, the first motion limited in hip disease, may be even increased in range.

Fracture of the Neck of the Femur in Childhood or Traumatic Coxa Vara.—Fracture of the neck of the femur in childhood is often of what may be termed the green-stick variety, a depression of the neck of the femur without actual separation of the fragments; and in many instances the patients are able to walk about within a short time after the accident. In such cases the limp and discomfort, attended during the stage of repair by a certain degree of muscular spasm, are often

mistaken for the symptoms of disease. The history of the accident followed by immediate disability; the shortening and the elevation of the trochanter, should establish the diagnosis.

Congenital Dislocation of the Hip.—Congenital dislocation of the hip causes a limp, but it is a limp that has existed since the child began to walk and that is unaccompanied by the symptoms of disease. The nature of the disability should be apparent on examination.

Hysterical Joint.—In hysterical subjects a limp, apparent pain and distortion of the limb, often following slight injury, may simulate disease.

Hysteria is very uncommon at the period of life in which tuberculous disease is most frequent. Patients suffering from hysterical joints usually present other symptoms of hysteria; the characteristic signs of disease, muscular spasm and atrophy, are absent; while the apparent discomfort and the voluntary distortion are quite out of proportion to the physical evidences of injury.

The X-Ray in Diagnosis.—Roentgen pictures are of far more value in demonstrating deformity than in establishing early diagnosis of disease, especially at the hip in early childhood, when so large a part of the extremity of the femur is cartilaginous. The pictures are of value, however, in showing the destructive effect of the disease on the head of the femur or acetabulum, and thus giving one a clearer conception of the actual condition of the joint than would be possible otherwise. (Fig. 168.) In older subjects it might be possible to demonstrate the presence of disease in the interior of the bone by this means, but in any event Roentgen pictures are of value only when interpreted by knowledge of the physical signs.

Method of Recording a Case.—The record should contain the general history of the patient together with an account of the more important symptoms, and of the treatment that may have been employed. The physical examination should include the weight and height, for comparison with the normal standard, and as a basis on which to judge the future progress of the case. Then follows a brief description of the gait and attitude; of the character of the distortion, if it be present, and of the changes from the normal contour. If restriction of motion be present, its causes are stated if possible; whether, for example, it is due to simple muscular spasm, or in part to adhesions and contractions. The presence or absence of heat and swelling, of abscesses, sinuses and the like, is indicated. If there is actual shortening of the limb its causes and distribution should be stated; whether it is the result of simple retardation of growth or of elevation of the trochanter, as may be ascertained by Nélaton's line and by Bryant's triangle. If the elevation is due in great part to the enlargement of the acetabulum, while the upper extremity of the femur remains fairly normal in shape, the projection of the trochanter is more noticeable, and the distortion of the limb in adduction is greater, than when the elevation is the result of destruction of the head of the bone. In this class of cases Roentgen pictures are of service in showing the actual condition of the joint. (Fig. 169.)

A condensed account of the more important points in the physical examination may be presented by the formula used at the Hospital for Ruptured and Crippled, as follows: R.A.—R.U.—R.T.—R.K.—R.C. —A.G.E.—A.G.F.—A.S.P.—L.A.—L.U.—L.T.—L.K.—L.C.

"A" indicates the distance from the anterior superior spines to the internal malleoli.

"U," from the umbilicus to the same points.

"T," "K" and "C," the circumferences of the limb at the thighs, knees and calves.

"A.G.E." indicates the angle of greatest extension.

"A.G.F.," the angle of greatest flexion. Thus the restriction of the range of antero-posterior motion at the hip is shown by these measurements.

"A.S.P." is the transverse diameter of the pelvis between the anterior superior spines, the measurement required in Lovett's table for ascertaining the degree of lateral distortion.

If, for example, the record read:

R.A. 18½—R.U. 20 —R.T. 11 —R.K. 8¾—R.C. 7¾—A.G.E. 150—A.S.P. 7
L.A. 18½—L.U. 21¼—L.T. 10¼—L.K. 8¼—L.C. 7¼—A.G.F. 90

it would show at a glance that there was no real shortening, that the leg was abducted because there was one and a-quarter inches of apparent lengthening, according to the table, the equivalent of ten degrees of abduction. It would show that there was permanent flexion of thirty degrees and a range of motion between the limits of flexion and extension of sixty degrees, as compared with the normal of about 130 degrees.

The following details from the one thousand cases of hip disease investigated for me by Dr. D. D. Ashley are of interest as illustrating the character of the cases treated at the Hospital for Ruptured and Crippled.

THE DURATION OF DISEASE WHEN TREATMENT WAS BEGUN.

Three months or less	396	Four years	21
Three to six months	170	Five years	17
Six months to one year	80	From five to ten years	35
One year	124	From ten to forty years	16
Two years	75	Not stated	37
Three years	29		1,000

THE DEGREE OF DEFORMITY PRESENT ON FIRST EXAMINATION.

No deformity	130	55 degrees of flexion	10
5 degrees of flexion	44	60 " " "	26
10 " " "	89	65 " " "	8
15 " " "	69	70 " " "	22
20 " " "	118	75 " " "	2
25 " " "	32	80 " " "	11
30 " " "	135	85 " " "	1
35 " " "	56	90 " " "	12
40 " " "	70	More than 90	1
45 " " "	41	Not stated	55
50 " " "	68		1,000

RESTRICTION OF MOTION AT FIRST EXAMINATION.

Normal motion	30
A range of motion through 105 degrees	14
" " " " " 90 "	65
" " " " " 75 "	49
" " " " " 60 "	95
" " " " " 45 "	67
" " " " " 30 "	112
" " " " " 15 "	95
" " " " " 5 "	157
No motion	147
Not stated	169
	1,000

ATTITUDE OF THE LIMB AT FIRST EXAMINATION.

Flexion to a greater or less degree	814
No flexion	130
Not stated	56
	1,000

OTHER DISTORTIONS RECORDED.

Abduction	254
Adduction	167
External rotation	166
Internal rotation	58

ACTUAL SHORTENING WHEN TREATMENT WAS BEGUN.

$\frac{1}{4}$ inch	129	$2\frac{1}{4}$ inches	5
$\frac{1}{2}$ "	143	$2\frac{1}{2}$ "	5
$\frac{3}{4}$ "	22	$2\frac{3}{4}$ "	2
1 "	51	3 "	2
$1\frac{1}{4}$ inches	9	$3\frac{1}{4}$ "	2
$1\frac{1}{2}$ "	16	$3\frac{1}{2}$ "	2
$1\frac{3}{4}$ "	6	$9\frac{1}{2}$ "	1
2 "	21		416

Shortening absent or not stated in 584.
Abscess was present in 105 cases.

Treatment.—The principles that should govern the treatment of a disease are best indicated by the study of cases that have received no treatment, and that show therefore the natural history of the affection.

A characteristic case of tuberculous disease of the hip joint begins insidiously. It causes a slight limp and at times a certain amount of pain. In the early stage of the disease there is slight flexion of the limb, usually combined with abduction, the instinctive assumption of the attitude of rest. As the disease progresses, the limb becomes less capable of performing its proper function; the range of painless motion becomes more and more restricted and the attitude changes to one of increased flexion and adduction, the attitude in which the limb is best protected from injury and in which it is least capable of performing its share of normal work. Pain is more constant, abscess is often present, and the constitutional effects of a depressing disease may be apparent.

This progression of symptoms and attitudes is so fairly constant, that hip disease is often divided into stages corresponding to these early and later manifestations of its effects. When the limb has reached the position of greatest protection, when motion which at first was limited only by the involuntary spasm of the muscles that are now atrophied, is restricted by adhesions and contractions, pain often ceases to be a troublesome symptom, the general health improves and effective repair begins. During the progressive stage erosion of the opposing surfaces of the joint has advanced, always more rapidly at the points of mutual pressure and friction, the upper and inner surface of the head of the femur and the upper margin of the acetabulum, and here the disease remains active while repair progresses at the points which have been relieved from irritation. Thus, in many instances, the upper margin of the acetabulum is destroyed and a subluxation of the femur takes place (Fig. 155), a displacement favored by the attitude of flexion and adduction and induced by pressure upon the limb. In some instances there is complete displacement, and when the diseased parts are thus separated from one another by this form of pathological excision, relief of symptoms and practical recovery may quickly follow, although sinuses leading to areas of local disease or to fragments of necrosed bone, may persist for many years.

Nature's cure of hip disease implies recovery with a shortened and distorted limb, a final result which is common enough even when treatment has been employed to explain the popular conception of what hip disease entails. (Fig. 165.)

There are many cases of hip disease in which the primary focus in the head of the bone is so limited in extent, that perfect functional cure may result under any form of treatment, or non-treatment even. And there are others in which the disease is of such a destructive character that the result must be disastrous in spite of treatment. But there can be no doubt that by early diagnosis and by efficient protection, a vast amount of suffering may be prevented, that useful function may be preserved, which would otherwise have been lost.

The object of treatment is to prevent the symptoms and the effects of the disease that have been outlined as characteristic of the untreated cases. To relieve the pain that depresses the vitality of the patient. To relieve the muscular spasm that induces distortion of the limb, and that stimulates the activity of the destructive process by increasing the pressure and friction of the diseased surfaces of the opposing bones. To correct and to prevent deformity and to prevent, as far as may be by lessening the pressure and by restraining motion, the upward displacement of the femur that causes irremediable distortion.

There are cases in which radical removal of the diseased parts may be indicated and there are times when acute symptoms may require absolute rest of the patient. But it is evident in the management of a chronic tuberculous disease, throughout the period of years that may elapse before cure is accomplished, that the requirements of treatment which have been indicated must be met, as far as may be, by appliances that allow exercise in the open air.

Mechanical Treatment.—The most effective treatment of a diseased joint is that which assures it the most perfect rest and protection. If the disease be in the earliest stage and confined to the interior of the bone, rest offers the most favorable condition for repair and for preservation of the joint. If the disease be further advanced, complete relief of function affords an opportunity for nature to check its progress and to preserve, it may be, a part of a joint from invasion. If the joint be already involved, rest offers the best opportunity for repair by preventing friction that stimulates the progress of the disease and increases its destructive effects. Whatever checks or retards the progress of the disease correspondingly relieves its symptoms and prevents the constitutional depression and thus preserves the vital resistance, both local and general, upon which the cure of the disease ultimately depends.

Rest of a diseased joint of the lower extremity necessitates splinting, stilting and traction.

Splinting naturally signifies the fixation that may be attained by the application of a splint, extending a sufficient distance on either side of the part to be fixed.

Stilting—the elevation of the foot from the ground so that jar and pressure on the diseased articulation may be removed.

Traction—a sufficient force exerted upon the limb to overcome and to control the spasmodic action of the muscles.

The knee joint, the junction of two levers of similar size and function may be easily controlled or placed at rest by means of apparatus. But the hip joint is a ball-and-socket joint which allows free motion in many directions, and being the junction of the body and the limb, two segments of different size and function, it is especially difficult to control. For this reason as much as any other, perhaps, the treatment of hip disease has been the subject of controversy for many years. And even at the present time one can hardly describe the treatment of hip disease adequately, without contrasting the methods of treatment that are in common use.

Such an exposition should begin naturally with a description of what has long been known as the American treatment, in which traction has always occupied the most important place.

The Traction Hip Splint.—The traction hip splint consists of a pelvic band and an upright. The pelvic band is made of sheet steel about a quarter of an inch in thickness and one and one-eighth inches in width, sufficiently strong to support the weight of the body without yielding, bent into a **U** shape to conform to the pelvis, but wide enough to cause no antero-posterior pressure. As Taylor puts it, there should be room enough for the pelvis to move freely in it. This band embraces about three-quarters of the pelvis at a point just above the trochanters. It is covered with leather and is provided with a strap to complete the circumference. Upon the pelvic band four buckles are placed for the attachment of the perineal bands. The two buckles on the front band are placed directly above the attachments of the adductor muscles, on

either side of the genitals. Behind, the buckles are placed much further apart, somewhat to the outer side of each ischial tuberosity, upon which, in great part, the weight of the body is to be supported. The pelvic band is bolted firmly to the upright at a slight inclination, corresponding to the inclination of the pelvis. The upright extends from the top of the trochanter to two or more inches below the sole of the foot. It may be made in one piece or in two sections overlapped and attached to one another by screws, to allow for adjustment. (Fig. 172.) It is turned inward at a right angle below the foot and is shod with leather or rubber. The foot piece may be provided with a windlass (Fig. 171), or the traction may be made by simple straps attached on either side. At about the middle of the upright is placed a support of light steel which is provided with a broad leather strap for the purpose of fixing the thigh to the brace and supporting the knee. In some braces a second similar support is placed at the upper part of the stem; in others the knee is supported only by a broad leather pad which covers its inner surface and is attached to a cross piece on the upright by straps, as in the Taylor brace. In the Taylor brace, which has served as a

Fig. 171.

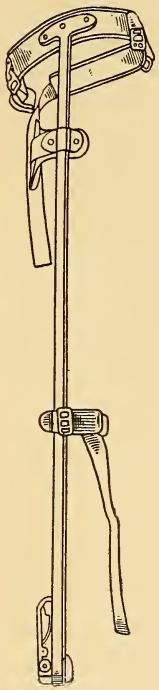


Fig. 172.

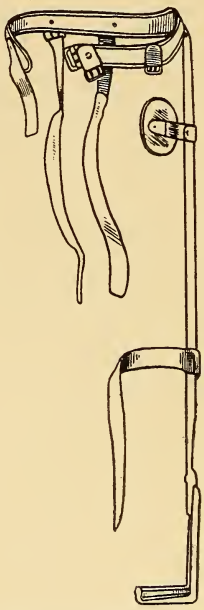
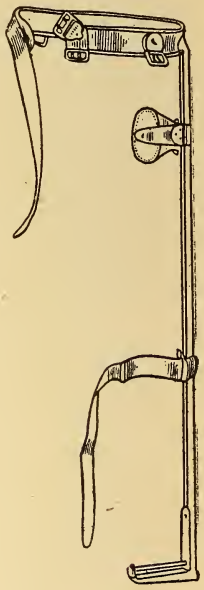


Fig. 173.



The traction hip splint with over-lapping upright and windlass, used at the Boston Children's Hospital. (Bradford and Lovett.)

model for all similar appliances, the upright is a steel tube into which slides a rod, supporting the foot part of the brace, the two parts being joined with a rack-and-pinion attachment and lock, so that the brace may be lengthened or shortened by means of a key. (Fig. 178.)

Traction Straps.—Traction upon the limb is made by adhesive plaster, preferably that known as moleskin (yellow) plaster which is far less irritating to the skin than rubber plaster.

These plasters should be cut into a shape corresponding to the lateral aspect of the thigh and leg, thus: wide above and narrow below, reaching from the trochanter on the outer, and from the pubes on the inner side, to the malleoli. (Fig. 195.) The lower ends are reinforced by a second layer of plaster and to them buckles are attached. The plasters are then applied to the limb and are held in place by a bandage which is smoothly applied and then sewed, to prevent disarrangement. The object of the bandage is primarily to assure the adhesion of the plaster and secondarily to keep it clean. It can be replaced by a properly fitted covering of stockinette or by a stocking leg.

Fig. 174.

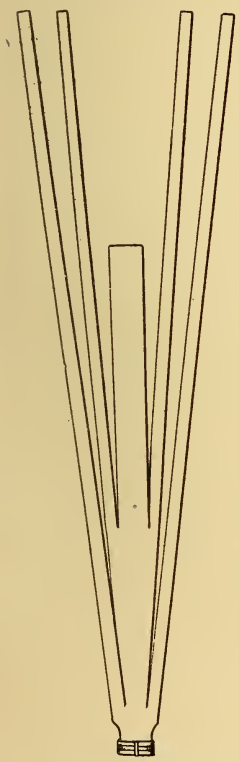
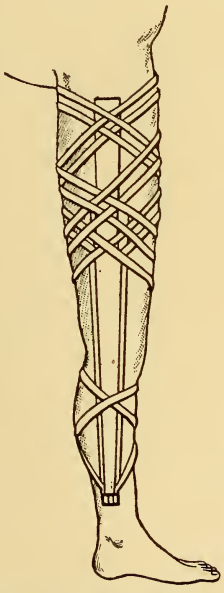


Fig. 175.

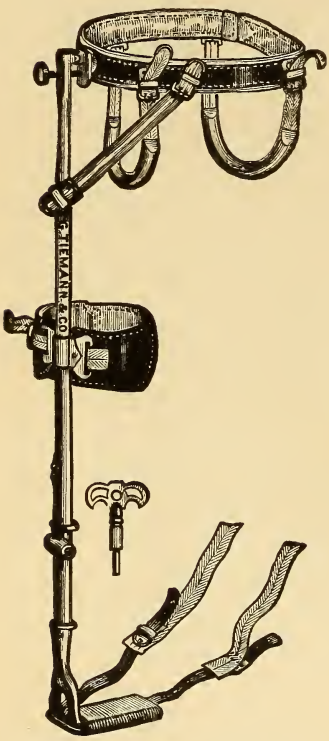


C. F. Taylor's method of applying adhesive plaster.

Another method of applying the plaster, designed to attain a better hold upon the limb, is that devised by Taylor, and described by him as follows: "The first important object is to seize the leg in such a manner as to exert against it an unyielding force. This should be done in such a manner as will not interfere with the circulation, nor injure the knee, by unequal strain either below or above it. In other words, the whole leg should be grasped in such a manner that the knee will be supported. It may be done as follows: A strip of adhesive plaster long enough to reach from the waist to the foot, and from three to five inches wide at the upper and about one-third that width at the lower end, is taken and cut into five tails as shown in accompanying illustration. (Fig. 174.) A piece from four to six inches long is cut from the center tail and added to the lower end to strengthen it; and, if the patient be strong, one or two more pieces are laid on the same place, where a buckle is attached. Two similar straps are prepared, one for the inside and one for the outside of the leg, and laid against the lateral aspects of the leg, the ends with the buckles beginning about two inches above the internal and external malleoli, and the center tails reaching the entire length of the leg and

thigh, to the perineum inside and the trochanter on the outside. The lower strips or tails are then wound spirally around the leg to the pelvis and afterward the other two pairs of tails, which are cut down to just above the knee, are also wound about the thigh in the same manner. When completed, the thigh is involved in a network of strips of adhesive plaster, which act equally and without pressure on the whole surface. The leg has about one-fourth of the attachments, and the thigh three-fourths, which is found to be the right proportion to protect the knee equally from compression or strain. A few turns of the roller bandage are then made around the ankle just under the lower ends of the straps, which serves as a protection to the flesh under the buckles, and then it is continued over the straps on the whole leg. Thus prepared, the patient is ready for the splint."

FIG. 176.



The traction hip brace. Original form.

At the Boston Children's Hospital the lower ends of the adhesive straps terminate in tapes that extend below the foot for attachment to the windlass, which is used with the cheaper form of brace.

Perineal Bands.—Perineal bands are made by covering a firm, wide, unyielding band of webbing with several folds of blanket or similar material and then binding it smoothly with canton flannel. These are made in different lengths and sizes, as may be required.

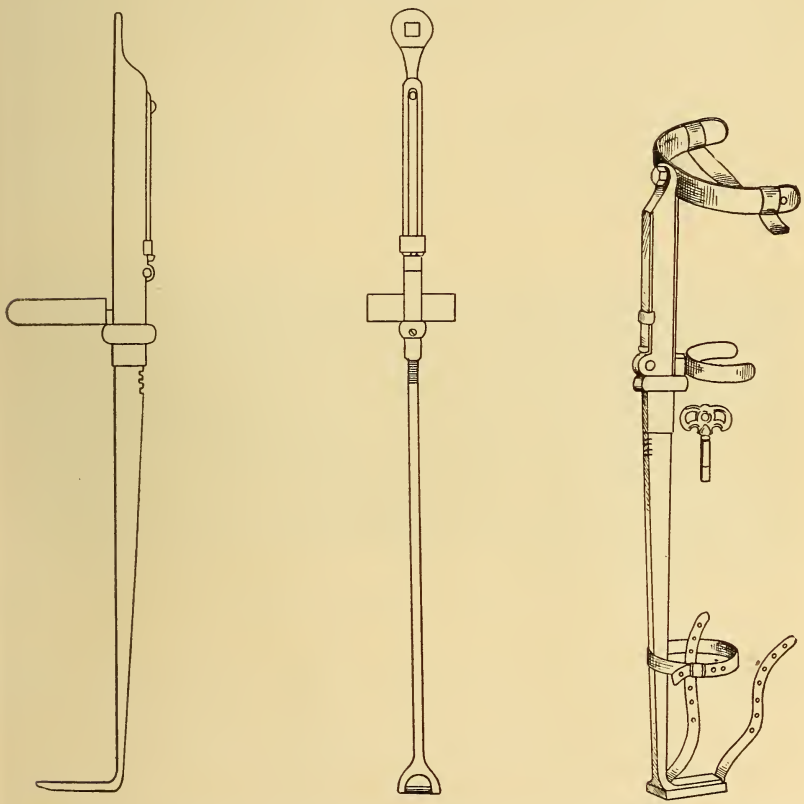
The "High Shoe."—The best and lightest material for raising the shoe worn on the sound foot to correspond with the brace is cork, and the ordinary thickness is two and a-half inches. A good and cheap substitute may be made of light wood provided with a leather sole, and in certain cases a patten of metal may be used.

The Application of the Traction Hip Splint.—The traction brace is applied in the following manner:

The patient lying upon his back, the pelvic band is first adjusted and strapped about the body. The perineal supports are then drawn firmly into place so that pressure on the upright does not move the pelvic band from its proper position just above the trochanter. The brace is then pressed upward against the resistance of the perineal bands, while the leg is at the same time drawn downward and is fixed by attaching the straps to the buckles at the ends of the adhesive plasters. If the brace is provided with a windlass or ratchet, further traction is applied to the point of tolerance by means of the key, care

being taken in adjusting the brace that it does not project so far below the foot as to more than equal the extra length provided by the high shoe on the sound side. The knee band is then adjusted and in many instances a strap is placed about the ankle and the brace to assure greater security. The shoe is then put on, the leg clothing is drawn over the brace and the patient is allowed to stand. If in walking the patient is inclined to tilt the foot downward and to bear the

FIG. 177.



The Judson brace. This has but one perineal band and the upright is bolted firmly to the pelvic band.

weight on the toe, a heel strap is attached to the foot piece to hold the foot in the horizontal position.

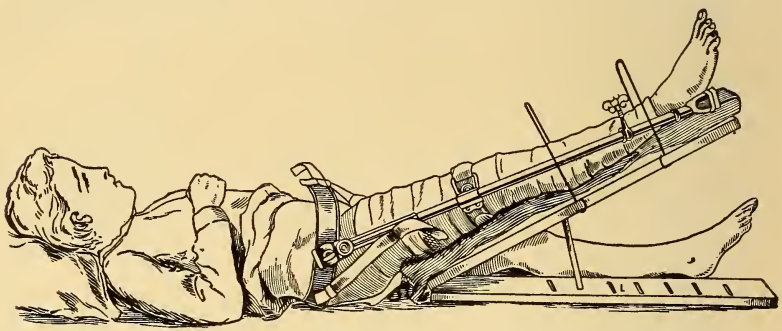
By means of this brace the weight is borne entirely upon the perineal bands, thus the joint is relieved from pressure and from jar. These perineal bands should be accurately adjusted to pass upward, in front, parallel to one another on either side of the genitals, in order to avoid pressure on the adductor region of the thighs; while behind, they turn diagonally outward in order to pass over the tuberosities, which are best adapted for weight bearing.

In the original Taylor hip brace the pelvic band is bolted to the upright in a manner to allow antero-posterior motion, and the inclination of the pelvic band is regulated by a strap attached to the upright. (Fig. 176.) This facilitates adjustment when the limb is flexed to a marked degree. This brace has been modified by Taylor by shortening and changing the shape of the pelvic band for the use of but one perineal support (Fig. 201); and a similar form of brace is used by Judson. The shortened pelvic band lessens the restraint of the brace upon the motion of the limb, and seems to offer little compensating advantage.

Before the traction brace is used in ambulatory treatment, distortion of the limb, if it be present, should be reduced; or if the disease be particularly acute, preliminary rest in bed, until the subsidence of the symptoms, is advisable.

The Reduction of Deformity by Means of the Traction Brace.—The patient lies in bed upon a firm mattress; the distorted limb is then raised to slightly more than a sufficient angle to relax the contracted

FIG. 178.



The reduction of flexion by means of the traction hip splint. (C. F. TAYLOR.)

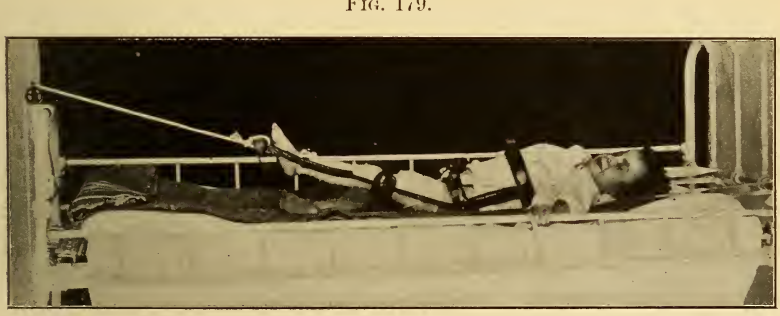
muscles and to straighten the lumbar lordosis; it is then abducted or adducted if necessary so that the level of the pelvis is restored. The pelvic band is made to conform to this greater relative inclination of the pelvis by lengthening the posterior strap; the brace is then applied, the limb being held in the attitude of deformity by a sling or support (Fig. 178), and as much traction as the patient can tolerate is exerted by lengthening the upright. The direct traction exerted by the brace may be reënforced by means of a cord running over a pulley at the foot of the bed, in the line of the brace, to which a weight of ten or more pounds (Fig. 179) is attached. Thus the pressure of the perineal bands is somewhat lessened. Efficient traction will quickly reduce recent deformity caused by muscular contraction, and as this is lessened the position of the limb is correspondingly changed, until it lies extended and parallel with its fellow. If adduction be combined with flexion the perineal band on the side opposite to the disease is tightened from time to time, or a direct push against the opposite adductor region is exerted by means of a bar attached to the brace opposite the knee. (Fig. 200.)

In ordinary cases the deformity may be reduced by this means in from two to six weeks.

The brace should be worn day and night. The perineal bands may be loosened at times to allow for bathing the skin with alcohol, and for powdering, in order that the skin may be kept dry; but at such times, if the disease be acute, manual traction should be made until the brace has been readjusted. The adhesive plasters, if of moleskin, may often remain in position for three months or longer. When they are removed the limb is gently bathed with alcohol. Excoriations are unusual unless rubber plaster is used. If the skin is abraded the part should be powdered with boracic acid and protected from the plaster by a layer of gauze.

The Relative Efficiency of the Traction Hip Splint.—In analyzing the action of this brace it is evident at once that it is thoroughly effective as a stilt. It is effective as a traction appliance, in the sense of relieving muscular tension, in direct proportion to the

Fig. 179.



A method of reducing flexion in hip disease. The brace is adjusted to the angle of deformity and in addition to the direct traction of the apparatus weights are attached to the brace itself. In the illustration counter-traction, by means of perineal bands attached to the head of the bed, is shown.

care that is exercised in its adjustment. Traction by this appliance may be made constant and effective, even to the point of practical fixation while the patient is in bed, or when crutches are used, in ambulatory treatment. But when the apparatus is used as a walking brace, as was designed by its inventor, constant traction is not exerted, for the traction straps alternately relax and tighten when the weight of the body falls upon and leaves the brace in walking. When the brace is off the ground the joint is subjected to the traction that the brace exerts, plus its weight, as contrasted with cessation of traction and the relief from the weight when the brace supports the body at the alternate step. Thus the critics of the brace assert, in somewhat exaggerated language, that it exercises a pumping action on the joint. As a matter of fact, the observation of patients, under treatment by this method, will show that little actual traction is exerted in the ordinary cases; that the so-called traction really serves principally for the adjustment of the brace, which by its weight, exercises a certain intermittent traction during locomotion. The hold of the encircling band

upon the pelvis assures a considerable restriction of motion, but whatever splinting action it may have depends upon the degree of traction, which is never effective enough, however, to prevent a certain amount of motion. This point is illustrated by the experiments of Lovett,[1] which are described by him as follows :

"In these experiments a long-traction splint was fitted with a self-registering pencil, by means of which motion at the hip joint was recorded upon the skin over the ilium. This was done simply by carrying the shaft up, so that it held the pencil perpendicularly to the skin. A splint fitted with this register was applied to a boy with normal hip joints, and traction was made up to the usual point, being about three pounds and a-half, as registered by a spring balance inserted in the extension straps. With this splint on, the boy was allowed to walk, and it was found that the hip described an arc of thirty-five degrees of joint motion. In sitting down and rising, an arc of similar extent was described. In another case with normal hip joints the motion was found greater, and the register showed a motion of forty degrees. With a very severe amount of traction—so much so that it was almost unendurable—motion of fifteen degrees was recorded. This apparatus was first tested by being applied to a patient with anchylosis of the hip, when it was found that no motion was recorded, the register marking by a dot. These experiments certainly seem to show that to a healthy hip joint the long-traction splint affords very imperfect fixation, and it may be inferred that to a diseased joint equally poor support is afforded."

The fact must be borne in mind that the traction hip splint was not intended to be a fixation or splinting appliance. On the contrary, Davis its inventor, Taylor, who changed it into a practicable form and Sayre, who further modified it, each believed that motion, except when the joint was fixed by muscular spasm, was desirable.

"The first splint, as well as all my modifications, admits of free motion of the diseased joint, but rigidly excludes all friction of the diseased surfaces upon one another."[2] (Davis.)

"Motion without friction is not only not injurious, but it is highly beneficial."[3] (Taylor.)

"For the ligaments around a joint will become fibro-cartilaginous or even osseous, if motion is denied them, particularly if a chronic inflammation is going on within the joint with which they are connected.

"As Dr. Davis is, I believe, the first person who constructed an instrument embracing these important advantages, extension with motion, I have given him full credit for the same, etc."[4] (Sayre.)

Motion without friction in this sense would seem to imply the actual separation of the femur from the acetabulum, or distraction as distinct from traction.

[1] R. W. Lovett, N. Y. Med. Jour., Aug. 8, 1891.
[2] Davis, Conservative Surgery, 1867, p. 214.
[3] Taylor, The Mechanical Treatment of Disease of the Hip Joint, p. 15, 1873.
[4] Sayre, Lectures on Orthopædic Surgery, p. 260, 1879.

That actual distraction is possible at the hip joint both in health and disease is proved by the experiments of Brackett[1] and by those of Bradford and Lovett. These experiments show that a traction force from ten to twenty pounds is required to cause one-eighth to one-quarter of an inch of actual lengthening of the limb, even in childhood; it is, therefore, to say the least, unlikely that the feeble and intermittent traction exerted by a hip splint, when used as an ambulatory support, can be sufficient to separate the bones from one another and thus to allow motion without friction, as was originally claimed for this apparatus. In fact it would appear that the claim that motion was of positive benefit to the diseased joint was afterwards modified by the upholders of this method of treatment to a negative assertion of its harmlessness, for example:

"If the disease permits a certain amount of motion at the affected articulation, motion within the limits set by nature is not harmful."[2] (Shaffer.)

This statement would seem to imply that the motion permitted by the apparatus might be varied in accordance with the degree of restriction that a particular case presented, provided that this motion were restricted to the limit set by nature; but in actual practice the same form of brace is applied, and with the same adjustment, in every case; or as it is stated in a paper on the final results of the mechanical treatment by this apparatus in dispensary practice, under Shaffer's direction: "In each case reported, a Taylor traction splint was applied soon after the first examination. * * * The patient, unless recumbency was necessary to overcome a malposition of the limb or unless the symptoms were so acute as to demand rest, was allowed almost unlimited exercise in the open air."[3] Yet it may be inferred from the report of the final results in these cases that in spite of the protection, which in many instances must have restricted motion within the limits present at the first examination, the range of motion became more and more restricted, for in 16 of 35 cases reported, anchylosis resulted; and in seven others the motion was less than ten degrees. Thus in 74 per cent. of the cases, practical fixation of the joint was found on the final examination.

In criticising these statistics it must be borne in mind that the patients were treated under all the disadvantages of dispensary practice, and that the final usefulness of a limb is by no means in proportion to the freedom of motion that may be preserved; still with these reservations it can hardly be claimed that the proportion of absolute or partial anchylosis would have been greater than this had any other system of treatment been employed.

At the present time the theory that motion of a diseased joint is of benefit, or that it is even harmless, has few supporters even among

[1] Brackett, Trans. Am. Orth. Ass'n, Vol. II.; Bradford and Lovett, N. Y. Med. Jour., Aug. 4, 1894.

[2] Shaffer, Trans. Am. Orth. Ass'n, Vol. II., p. 100.

[3] On the Ultimate Results of the Mechanical Treatment of Hip Joint Disease. Shaffer and Lovett, N. Y. Med. Jour., May 21, 1887.

those who use the traction brace exclusively. On the contrary, the motion that is recognized as unavoidable with the use of the apparatus is excused because of the practical efficiency of the brace and because it is believed that no more effective rest can be attained by any other method of ambulatory treatment.

In all acute cases a period of rest in bed with traction to the point of actual distraction, is advised. When ambulation is resumed the braced limb is made pendant by means of the high shoe and crutches, so that uninterrupted traction may still be exerted, and the brace is only used as a supporting appliance when the symptoms indicate that the disease is quiescent.

Although this modification of treatment was not followed by Taylor, still in his later writings he states that motion is of advantage only in the stage of recovery. And it is very evident that his success was due to the extreme care which he exercised in the supervision of the patients, and in adapting treatment to the varying phases of the disease, rather than to any theory that he may have advocated.[1]

As has been stated, treatment by the long-traction brace by means of which motion without friction was at one time claimed to be possible, and in which traction is the distinctive feature, is sometimes called "The American Treatment of Hip Disease." In this sense, the direct splinting of the joint without traction, by means of the Thomas brace, might be called in distinction "The English Treatment."

The Thomas Treatment of Hip Disease.—H. O. Thomas,[2] of Liverpool, writing at a time when in America it was generally believed that motion was essential to the well-being of a diseased joint, and when fixation was supposed to predispose to, or to actually induce, anchylosis, states "that continuity of extension *per se* is not a remedy in hip joint disease; in its application it involves unavoidably a fractional degree of fixation which is sufficient to mask the evil of this ridiculous malpractice."

The conclusions on which his treatment is founded are these: "The main obstacle to the cure of an inflamed joint is the friction and pressure of its surfaces; consequently the attainment of rest, that is of immobility of the articulations, ought to be the principle which should guide the treatment. Pressure and concussion are less to be feared than friction. Effectual rest can only be obtained by mechanical treatment and for this purpose the appliances which I here recommend are effectual. The more an inflamed joint is moved the stiffer does it become; while the more effectually it is fixed, the sooner and the more completely is its capability of movement restored. To insure permanency of cure, the control should be maintained for a period beyond the time when resolution has taken place. This prolonged arrest of a joint's movements, for even an unnecessarily long period, I have never found to do harm."

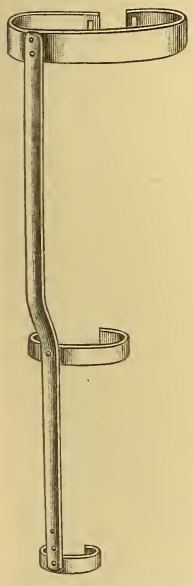
The splint used by Mr. Thomas to carry out these principles effectively is described by him substantially as follows:

[1] Boston Med. and Surg. Jour., March 6, 1879.

[2] Diseases of the Hip, Knee and Ankle Joints, treated by a new and effective method, 1875, p. 10.

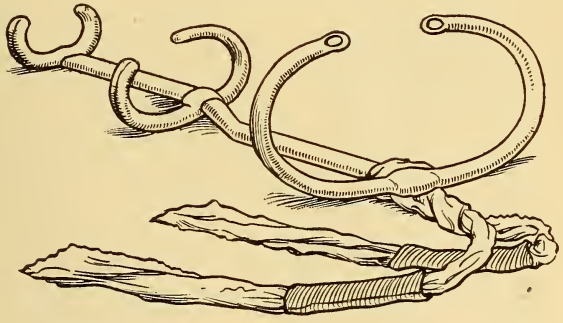
A flat piece of malleable iron, three-quarters of an inch wide and three-sixteenths of an inch thick for children, and one inch by one-quarter inch for adults, long enough to extend from the lower angle of the scapula to the middle of the calf, forms the upright. This is fitted to the body of the patient, passing from the lower angle of the scapula, in a perpendicular line, downward, over the lumbar region, across the pelvis, slightly external, but close to the posterior spinous process of the ilium and the prominence of the buttock, along the course of the sciatic nerve to a point slightly internal to the calf of the leg. It must be carefully modelled to this track. The lumbar portion of the upright must be invariably almost a plane surface, but it must be twisted slightly on its long axis at the junction of the upper and middle third, so that the anterior surface of the lower section may look slightly outward to correspond to the contour of the buttock and thigh. A second and double bend is made in the upright at the point where it passes the buttock, so that the thigh portion lies on a slightly higher plane than

Fig. 180.



The splint in its simplest form, not yet padded or covered. (Ridlon.)

Fig. 181.



The Thomas hip splint, covered and fitted with shoulder straps. (Ridlon and Jones.)

the body part, but parallel with it. The upright is then provided with chest, thigh and leg bands.

The chest band is of hoop iron one and a-half by one-eighth of an inch. This is bent into an oval to correspond with the shape of the chest, being four inches less than its circumference at this point if the patient be an adult, and of a corresponding size for a child. This band is riveted to the upper extremity of the brace, so that one-third of its length shall be on one side of the disease and two-thirds on the other. The thigh band and leg bands are of similar material, three-quarters by one-eighth of an inch in size. The thigh band, in length equal to two-thirds of the circumference of the thigh, is fastened to the upright at a point one to two inches below the buttock, and the calf band, equal in length to half the circumference of the leg at the calf,

is riveted to the lower extremity of the brace. Both the thigh and leg bands are attached to the brace at points slightly to the inner side of the center, so that the outer arm of each band is somewhat longer than the inner. The brace is padded with thin boiler felt and is covered smoothly with basil leather. In fitting the brace to the patient the long part of the chest band should be made to hug the body closely, while the short arm should be somewhat away from it. The anterior surface of the thigh part of the upright should have a perceptible outward twist and should be somewhat on the inner side of the popliteal space. Thus the instrument is prevented from rotating outward and becoming a side splint. The chest band is closed with a strap and buckle and suspended by shoulder straps and the leg between the two

FIG. 182.

Method of changing the line of pressure on the skin from the Thomas hip splint. (RIDLON AND JONES.)

bands is attached to the brace by means of a flannel bandage. Ridlon states that in practice this bandage is usually replaced by a strip of basil leather passed across the front of the leg close down to the upper border of the patella, thence backward and downward to the stem of the splint and pinned to the covering, so that any downward working of the splint would be brought to bear on the quadriceps femoris muscle. The shoulder straps also may be replaced by a single bandage looped about the upper part of the stem. (Fig. 182.) This bandage is twisted for a length of about six inches, then separated, the ends being carried over the shoulder, passed through holes in the corresponding ends of the chest band where they are knotted, and finally the two ends are tied to one another completing the circumference of the chest band.

This brace is fitted by the surgeon directly to the patient's body as

he stands erect. If the limb be already flexed, the foot is raised by blocks until the lumbar lordosis is straightened; the brace is then adjusted to the angle of deformity and is applied in the usual manner.

The brace is made of iron because it is less elastic than steel and because it can be more easily twisted by wrenches. It must be heavy and strong in order to splint the part effectively and it can only be an effective splint when it is fixed in its proper position and exercises direct pressure upon the hip joint. In cases in which the brace has been properly employed a deep furrow should be seen in the buttock directly over the neck of the femur. Once fitted to the patient it is changed only at intervals and always by the surgeon who is particularly careful not to move the limb during the active stage of the disease.

The double Thomas hip splint is made by joining two single splints. These are riveted to the chest band above and are connected at the lower ends by a crossbar, unless the brace is to be used in the reduction of deformity. Care must be taken that the uprights pass to the outer side and not directly over the posterior superior spines of the ilium.

FIG. 183.

Thomas splint applied with patten and crutches.

The Reduction of Deformity by the Thomas Method.—Preferably in the treatment of children the double brace is applied, the sound limb being fixed in the extended position while the flexed limb is supported by the other arm of the brace, bent to the angle of deformity. The patient is confined to the bed and as the muscular spasm relaxes under the influence of enforced rest, the brace is straightened slightly by wrenches from time to time, at a point opposite the joint, to conform to the improved position until symmetry is restored. In resistant cases this gradual relaxation is hastened by straightening the brace somewhat at intervals, to which the attached leg must conform—a gradual forcible reduction of deformity.[1]

The treatment is divided by Mr. Thomas into stages.

1. A preliminary stage of rest in bed for the reduction of deformity and to allow for subsidence of acute symptoms.

[1] Ridlon forces the flexed limb to conform to the straight Thomas brace unless the deformity is extreme. This is made possible by an exaggeration of the lumbar lordosis and by a corresponding increase of intra-articular pressure as illustrated by Marsh's diagram (Fig. 183).

2. The patient is then allowed to go about on crutches wearing an iron patten at least four inches in height under the sound foot. (Fig. 183.)

3. When all symptoms of disease have subsided and when atrophy of the muscles is marked the brace may be removed at night.

4. The brace is finally discarded but the patten and crutches are still used in walking.

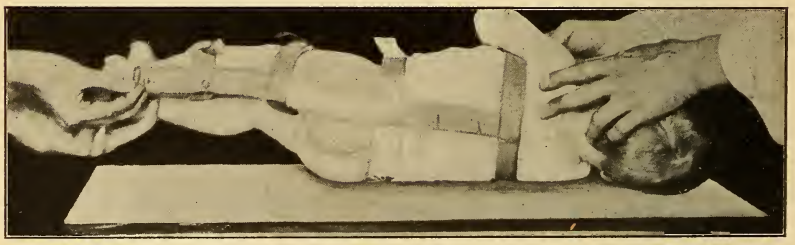
According to Ridlon[1] the records of Mr. Thomas show the average time of confinement to the bed to be twenty-two weeks, and the average duration of treatment twenty-one months.

It is stated by Ridlon[2] that in actual practice these principles were not carried out, for nearly all the children treated under Thomas' direction at the time his observations were made, were walking about without the high patten and crutches, even before the deformity had been overcome and while muscular spasm and pain persisted.

This was, however, probably an exigency of practice among the poor, and at all events it is in line with Thomas' contention that pressure and concussion are less harmful than friction.

Modifications of the Thomas Brace.—Although not so stated in his book, Thomas used at times a short brace extending only to the lower part of the thigh, thus permitting motion at the knee. This was apparently designed as a convalescent splint, although its use was

FIG. 184.



A form of Thomas brace employed in the treatment of infants. The screws at the lower extremity are arranged to permit the addition of a foot piece for traction.

not restricted to that class of cases. In certain cases a strip of iron, "the nurse," was screwed to the lower extremity of the long brace, prolonging it beyond the foot in order to prevent the patient from bearing weight upon the limb.

The Thomas brace, so effective in preventing and overcoming flexion deformity, is correspondingly inefficient in antagonizing lateral distortion. In fact in twenty-four of the fifty-eight patients examined by Ridlon,[3] adduction was present; a larger proportion, it would appear, than would be found in a like number of cases under treatment with the traction brace. This tendency to lateral distortion may be guarded

[1] Trans. Am. Orth. Ass'n, Vol. I., p. 17.

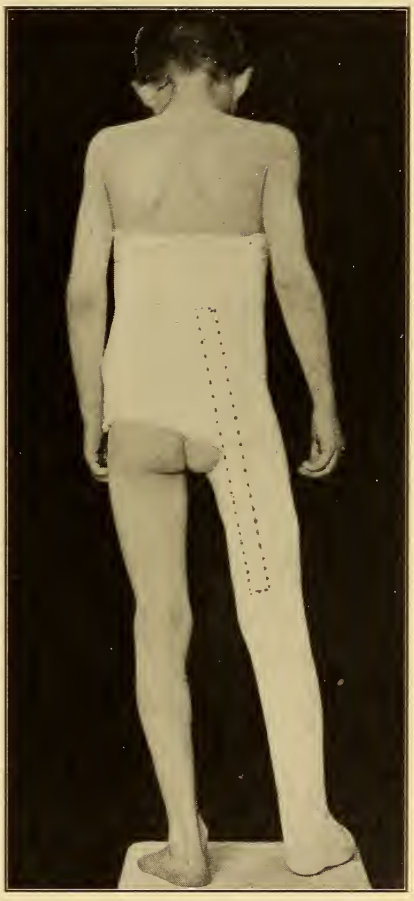
[2] A report of 62 cases of Hip Disease observed in the practice of Hugh Owen Thomas. N. Y. Med. Jour., Oct. 4, 1890.

[3] Loc. cit.

against by placing a half band of material similar to the chest band, about the side of the pelvis; on the same side for adduction, on the opposite side for abduction of the limb.

The Thomas brace has a great advantage over other appliances in its simplicity. It can be made by a blacksmith and it must be fitted by the surgeon. This fitting requires great care. In the words of Mr. Thomas, "the fitting although sometimes successful in one visit, may at other times occupy many days. The surgeon should mould, by reducing or increasing the various curves, until the instrument ceases to tend to rotate, and at none of its angles irritates the patient." He concludes in a general answer to the criticisms that have always been made on the difficulty of adjustment of the appliance, as follows: "What I can invariably do must be possible to others."

FIG. 185.



A plaster spica bandage. The dotted line indicates the position of the steel support.

Treatment by the Plaster Bandage.—A third method of treatment is that by means of the plaster bandage without crutches or high shoe. This is simple splinting with whatever protection from concussion the support may assure.

This treatment might be called the German method, if the traction hip splint and the Thomas brace are to be designated as American and English.

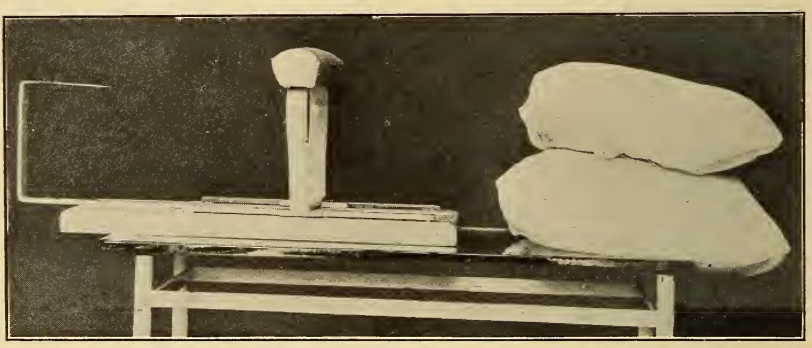
As used in the Surgical Clinic at Berlin, the plaster bandage is applied from the line of the nipples to include the foot, the limb being fixed in an attitude of slight flexion, abduction and outward rotation. As a rule the first bandage is applied under anæsthesia for the purpose of relaxing the muscular contraction and facilitating the application. If nutritive shortening of the muscles is present, sufficient force is employed to overcome the deformity. The spica is renewed at intervals of from two to four months. When the disease is cured and the bandage is finally removed, traction at night is employed for a time, by means of a

weight attached to the foot, to prevent the tendency to distortion. In ambulatory treatment this method has little to recommend it except expediency, but as a temporary support to be used before the application of a suitable brace, the plaster spica is most useful.

The plaster of Paris spica bandage when properly applied, is an admirable support, often far more comfortable to the patient than any splint, and it is at times an indispensable form of dressing. It is criticised for the same faults as the plaster jacket and it may receive the same defense, that the most severe critics have had the least experience in its use.

Application of the Plaster Spica Bandage.—A plaster bandage to assure support should fit perfectly, consequently it should be applied as closely as is possible, directly upon a layer of canton flannel, in place of the thick sheets of cotton wadding that are often used to envelop the body and the limb; only the bony prominences of the ilium, the knee and the heel require other protection. The bandage should cover

FIG. 186.



A modification of the Lorenz hip rest used at the Hospital for Ruptured and Crippled in the application of the plaster spica bandage.

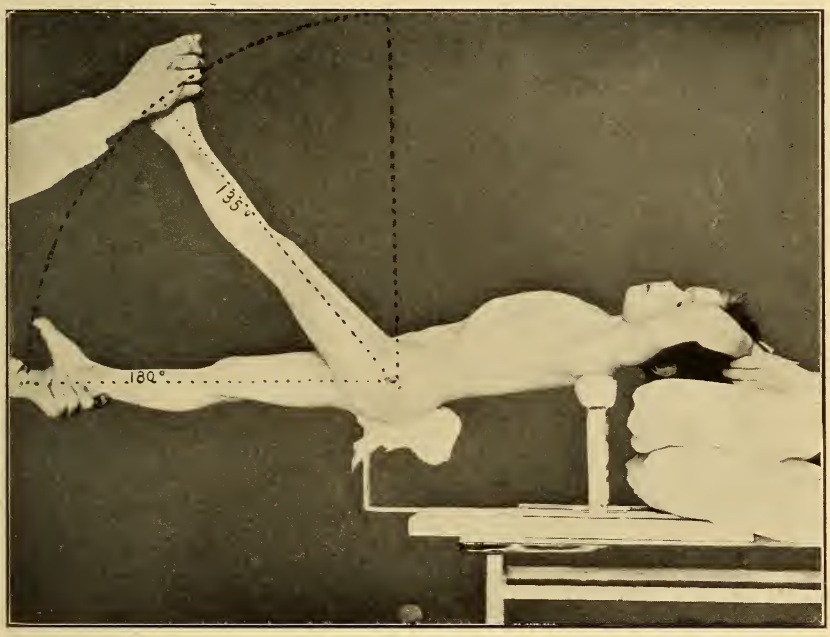
the lower half of the thorax, and it should extend to the ends of the toes. It should be applied under slight extension, drawn closely around the adductor region and the buttock, which should be entirely covered and supported. At this point, in the line in which the bar of the Thomas hip splint runs, a piece of splint wood or a strip of malleable steel, long enough to reach from the middle of the back to the lower third of the thigh, should be incorporated in the plaster. (Fig. 185.) A similar piece is sometimes placed in front of the hip and another beneath the knee, the points at which the bandage is likely to break. The proper support of the buttock, consequently of the hip joint, is almost invariably neglected in the ordinary application. The bandage may be applied in the upright posture by means of the swing, as used in the application of the plaster jacket, the weight being supported in part by the sound leg while the other is pendant. Or it may be applied with the patient in the reclining posture, the body being supported by a

shoulder rest, and the pelvis by the sacral support of Lorenz. The arms are then drawn above the head to increase the capacity of the thorax, while the two legs are supported by an assistant. (Fig. 187.)

In the more recent cases, deformity may be practically reduced at the second application of the bandage, because of the relaxation of the spasm assured by the rest and fixation; thus it is particularly useful in the treatment of young children in the outdoor practice, for whom hospital care would otherwise be required.

Immediate Reduction of Deformity.—In the more resistant cases an anæsthetic may be administered. If the deformity be due sim-

Fig. 187.



The hip rest in use. The patient presents fixed flexion to 135 degrees and fixed adduction of 35 degrees.

ply to muscular spasm the limb may be placed in the proper position without force, but if, as is often the case when the distortion is of long standing, it is caused in part by shortening of the muscles and fasciæ, a certain amount of force may be required. The pelvis should be fixed and the force should be applied as far as possible by direct extension rather than by leverage. Subcutaneous division of the contracted tissues about the anterior superior spine and in the adductor region, may be required. In very resistant cases the reduction of deformity by this method should be divided into several operations. Lorenz[1] reduces the adduction deformity by means of a machine that

[1] Lorenz, Sammlung Klin. Vor., 206, Leipzig, March, 1898.

exercises direct traction on the adducted limb while the sound limb is pushed upward, so that practically no leverage is exerted on the joint. In cases in which the deformity is accompanied by abscess, or when the joint is surrounded by infiltrated tissues and by sinuses this treatment should not be employed. In fact in certain cases of this class, especially when subluxation is present, it is often advisable to disregard the deformity that cannot be reduced by traction until the disease is cured, when it may be overcome by osteotomy of the femur. (See page 293.)

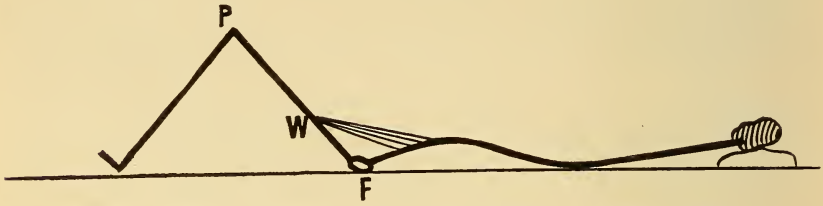
The immediate reduction of deformity by this method, properly performed, is free from danger; and it has become almost the routine of practice in the indoor department of the Hospital for Ruptured and Crippled. It has the great advantage of permitting the limb to be fixed in the proper position during the stage of recumbency, instead of employing this time for its gradual reduction.

Three methods of reduction of deformity have been described:

1. By means of the traction splint.
2. By means of the Thomas brace.
3. By means of the plaster bandage, with or without anæsthesia.

A fourth method is that by means of the weight and pulley. This is in common use because it requires no special apparatus.

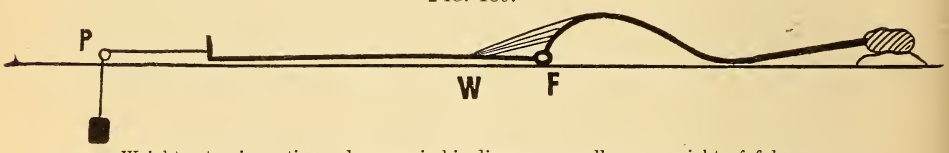
FIG. 188.



Posture of the limb in hip disease in which extension acts as leverage. *p*, pulley; *w*, weight; *f*, fulcrum.

REDUCTION OF DEFORMITY BY THE WEIGHT AND PULLEY.—The traction plasters are applied to the limb in the manner already described and the patient is placed on his back on a narrow firm mattress. The limb is then raised until the lumbar vertebræ rest upon

FIG. 189.

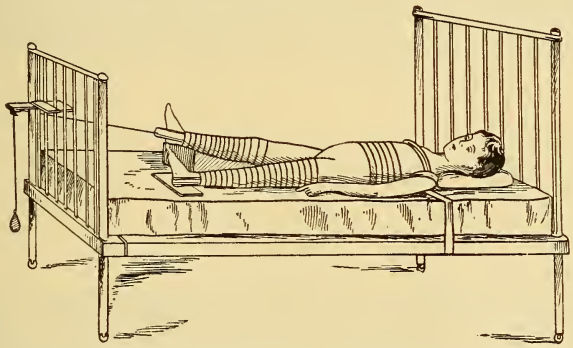


Weight extension acting as leverage in hip disease. *p*, pulley; *w*, weight; *f*, fulcrum. Marsh's diagrams, illustrating the advantage of traction in the line of deformity, in order to avoid leverage. (HOWARD MARSH.)

the bed and it is then moved to one or the other side, if lateral distortion be present, until the level of the pelvis is restored. In this position the limb is supported on a pillow, or better on the adjustable tri-

angle used with the traction hip splint. (Fig. 178.) A pulley or wheel is then attached to the foot of the bed in a prolongation of the line of the elevated leg. This wheel may be screwed to the top of a narrow board, which may be raised or lowered on the foot of the bed as required. To the buckles on the plaster traction straps a stirrup carrying the cord is attached. This stirrup is simply a spreader of narrow thin wood, slightly wider than the foot, provided at either end with straps or tapes, its purpose being to prevent direct pressure on the malleoli. (Fig. 193.) By means of a weight suspended at the bottom of the bed traction is made upon the limb to the extent that the comfort of the patient will permit. As in Buck's system of extension, the foot of the bed is raised to increase the friction of the body and thus to counteract the traction force, but in the treatment of children this is inefficient and counter traction must be provided. A simple method is to attach two perineal bands, as described in connection with the traction brace, to strong tapes that pass above and below the patient's body, to be fixed

FIG. 190.



Extension in hip disease. Marsh's method of fixing the patient in bed with shoulder straps and a long T splint on the sound side. (HOWARD MARSH.)

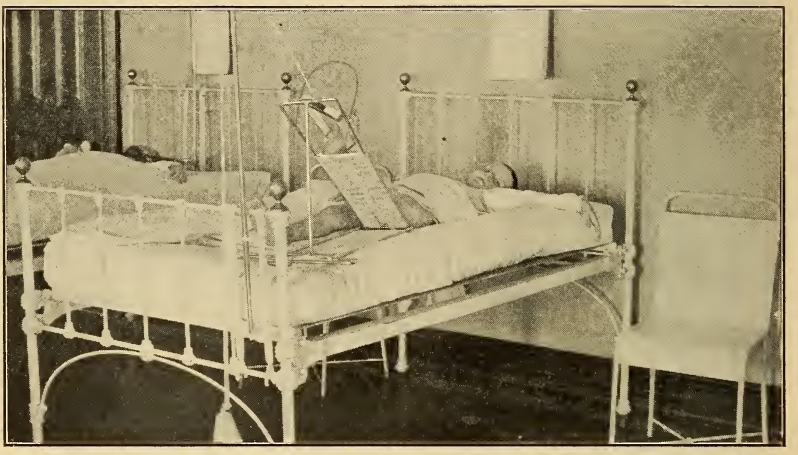
to the head of the bed at a suitable distance from one another, thus the pelvis is supported by prolonged perineal bands.

In order to assure efficient and constant traction the patient must be prevented from sitting up. For this purpose a swathe about the body, or shoulder straps may be applied and attached to the bed.

A convenient appliance is that of Marsh. "This consists of a piece of webbing, passing across the front of the chest, and ending in two loops, through which the two arms are passed, and through which is threaded another piece of stout webbing, which runs transversely across the surface of the bed under the child's shoulders, and is fastened at its two ends to the sides of the bedstead. When this is in action the patient's shoulders are kept flat on the bed, so that he can neither sit up nor turn on his side. This chest band does not cause the slightest discomfort. It is not, of course, fixed tightly, and when the child finds that he cannot sit up, he makes no further attempt to do so; and as he lies flat the band is loose."

It is better however to use some form of apparatus to fix the patient more thoroughly. Marsh uses a long lateral splint of thin board

FIG. 191.



Traction by means of weight and pulley. (R. T. TAYLOR.)

reaching from the axilla to a point below the sole of the foot where a crossbar is attached. To this the patient's body and sound limb are bandaged. (Fig. 190.)

FIG. 192.

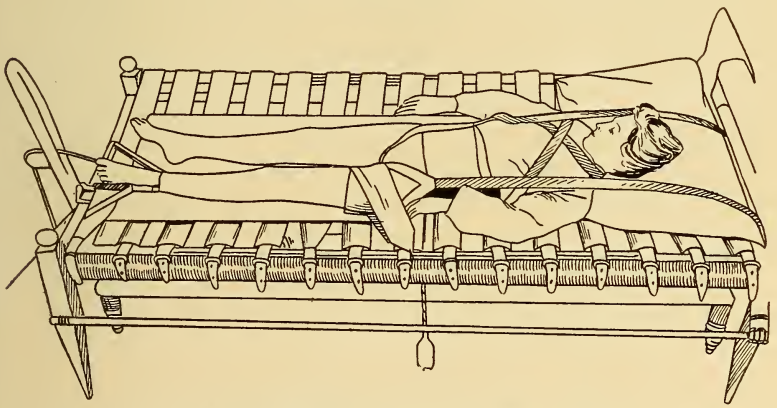
Method of fixing the patient to the Bradford frame for traction in hip disease. (R. T. TAYLOR.)

A plaster spica bandage or a Thomas splint may be employed on the sound side, but the most convenient appliance is the frame of gas

pipe covered with canvas, that has been described in the chapter on Pott's disease. Upon this frame the patient can be fixed, the limb being elevated by a support attached to the frame or independent of it. (Figs. 191, 192.) It is perhaps needless to suggest that the bed clothes must be held from the elevated limb, in fact, that the patient must for a time be enclosed in a tent of bed clothes, if the deformity is extreme. At first the traction weight must not be great, but as the perineum becomes accustomed to pressure, as much weight as can be tolerated is used, from ten to twenty pounds being the average. This may be reduced at night and increased during the day. Great care must be taken to prevent painful pressure on the perineum by careful adjustment and frequent inspection of the perineal bands.

If the frame is used it may be provided with a windlass at the bottom for traction and with an arched band of metal across the pelvis for the attachment of the perineal bands which behind are fastened to the side bars at a higher level. Thus the frame may be made an independent recumbent splint on which the patient may be moved about. If, however, one desires to exert traction to the point of distraction, the weight and pulley arrangement will often be required; in this case the limb should be placed in an attitude of slight flexion and abduction so that the femur may be drawn more directly from the acetabulum.

FIG. 193.



Lateral and longitudinal traction in hip disease. (PAGE.)

Lateral Traction.—Thus far longitudinal traction has been considered, but lateral traction or traction in the line of the neck of the femur deserves some consideration.

Mr. Thomas, who condemns all forms of traction as deceptive and irrational, and especially longitudinal traction, speaks thus of lateral traction. "For surely if relief from pressure be required, the only direction in which this is possible is clearly in the axis of the neck of the femur. Any method of extension in the axis of the body merely transfers the pressure from the upper part of the acetabulum to the

lower quarter." [1] This contention is purely theoretical as there is no evidence to show that injurious pressure is ever exerted upon this part of the acetabulum. On the contrary, the specimens from subjects who have been treated by longitudinal traction in recumbency and by means of the traction hip splint, almost invariably show the effect of pressure upon the upper part of the head of the femur and upon the upper adjoining margin of the acetabulum. Moreover, the neck of the femur is in childhood so short and is set upon the shaft at so great an angle, that longitudinal traction, if the limb be slightly abducted, is practically speaking in the line of the neck; so that even from the theoretical standpoint, the question of injurious pressure could only arise in the treatment of adults. The advantages of lateral traction in the treatment of hip disease have been urged with great persistency by A. M. Phelps,[2] since 1889, and it has been applied as a routine practice in ambulatory treatment by Blanchard,[3] of Chicago, since 1872.

The effect of lateral traction in recumbency has been carefully investigated by C. G. Page.[4] His conclusions are that lateral traction alone is of no benefit, but if applied, together with longitudinal traction, it gives great relief in some acute cases. The longitudinal traction should be twice as great as the lateral, ten and five pounds being the average weights employed in his experiments. The method is shown in the illustration. (Fig. 193.)

The Relative Efficiency of Traction and Splinting ("Fixation").

In considering the vexed question of the relative merits of splinting and traction in preventing muscular spasm and the consequent intra-articular pressure which causes pain and increases the destructive effects of the disease, these facts must be borne in mind.

The more acute the disease the less the ability of the joint to carry out its proper function, which is motion. The greater the motion under these circumstances the more intense the muscular spasm of which the object is the prevention of motion. If it were possible therefore to fix the joint absolutely there should be no muscular spasm, although the tension of acute disease within the bone, or of its products within the joint, might cause pain.

When the patient is fixed in the recumbent posture it is possible to apply a sufficient traction upon the muscles to prevent the contraction that causes injurious pressure, and although no amount of traction will absolutely prevent motion, yet with the support that the bed provides, practically speaking, complete rest may be assured. Only in the exceptional cases in which the tension upon congested tissues about an acutely inflamed joint is intolerable is this method of treatment inefficient.

The same statement is true of a properly applied spica bandage or Thomas brace, when the patient is recumbent, that it assures practical rest; thus it prevents muscular contraction, relieves the symptoms and

[1] Loc. cit., p. 10.
[2] N. Y. Med. Record, May 4, 1889.
[3] Trans. Am. Orth. Ass'n, Vol. VII.
[4] C. G. Page, Bost. Med. and Surg. Journal, Sept. 13, 1894.

promotes repair, although it cannot be claimed that the surfaces of the opposing bones are actually separated from one another.

But what is true when the patient is recumbent is not true of ambulatory treatment. The traction exerted by the hip splint even when the limb is pendant is far less effective than in recumbency, and when it is used as a walking appliance, for which it was designed and for which it is practically always employed, the traction is intermittent and of doubtful efficiency. The same loss in efficiency in less degree occurs in all forms of fixative apparatus when used in ambulation.

The Removal of Direct Pressure—"Stilting."—But granting that the traction brace as a walking appliance is relatively inefficient in preventing motion, and that motion without friction, provided the joint surfaces are actually involved, is impossible, still it cannot be denied that the traction brace is, or may be, at all times an effective stilt in that it protects the joint from concussion and pressure by removing the foot from contact with the ground.

It is true that the removal of direct pressure may be attained by the use of axillary crutches, but in Thomas' practice, they were used in but few cases.[1] In fact it is only by constant supervision that the use of crutches can be enforced upon children who no longer suffer pain, and as it is practically impossible to prevent the patient from bearing weight upon the limb, stilting by this means is relatively inefficient.

That direct pressure is one of the causes of upward displacement of the femur may be inferred from the statistics of Sasse and Bruns,[2] from the surgical clinics of Berlin and Tübingen where the routine of treatment is the plaster bandage, without the high shoe or crutches. In two-thirds of Sasse's and in four-fifths of Bruns' cases there was upward displacement of the trochanter. This is certainly a larger proportion than would be found in a corresponding class of patients treated by efficient stilting, although statistics on this point from American sources are lacking.

In the final comparison of the claims of traction and fixation, it is of interest to note that the most enthusiastic advocate of the Thomas treatment in this country, was trained in the use of the traction hip brace at the New York Orthopædic and Dispensary Hospital, an institution founded by Taylor and in which his methods have been closely followed. Ridlon states that an experience in the treatment of eleven hundred cases by the traction hip splint, led him to discard it in favor of the Thomas brace.[3]

The Practical Combination of Traction—Splinting and Stilting.—Thus far, the methods of treatment by splinting and traction have been presented as if they were necessarily opposed to one another in principle, and as if the theory were still held, that motion without friction is possible ; and as if it were believed that anchylosis is caused

[1] Ridlon, loc. cit.

[2] Sasse, Arbeit aus der Chir. Klin., Berlin, 1896. Bruns, Archiv. für klin. Chir., Bd. 48, H. 1.

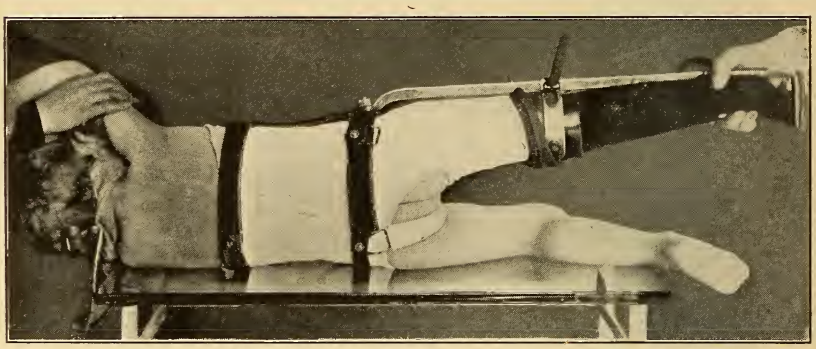
[3] Ridlon, Trans. Am. Orth. Ass'n, Vol. II.

by fixation and is prevented by the motion of a diseased joint. At the present time, however, it is generally recognized that the principle involved in both methods is the same, and that the actual merit of each must be decided by practical experience rather than by argument. The true test of the relative value of a routine of treatment is its efficacy in hospital practice, where its weak points cannot be supplemented by the careful supervision that may make almost any treatment that carries out in some degree the proper principle, effective. This test is all the more necessary because the great majority of cases of this character are to be found among the poor.

From this point of view the writer's experience may be of interest. His early training was entirely in the traction method, but the observation of a large number of cases in which this treatment was used, led to the following conclusions.

In one sense the treatment was successful, in that it in great degree relieved the symptoms throughout the greater part of the course of the disease and enabled the patients to go about in the open air, to attend

FIG. 194.



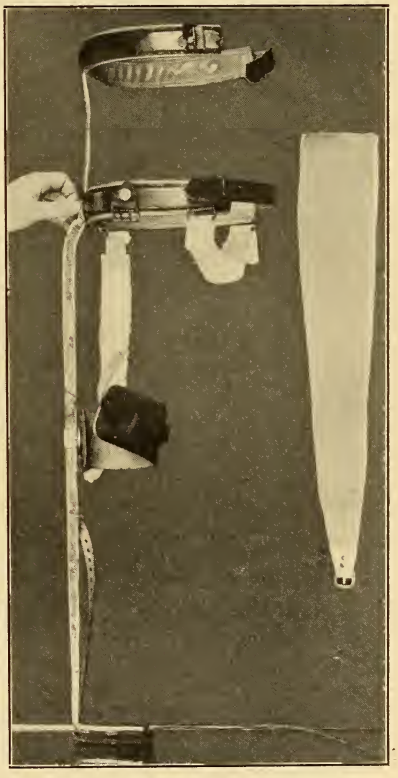
The short spica bandage in combination with the brace, one perineal band has been removed in order to show how the joint is supported by the bandage.

school and even to join in the games of their fellows. It was evident however, from an inspection of the patients as they returned for treatment, that the relief of symptoms was due to the protection insured by the stilting or crutch-like action of the brace and not by the traction, which was usually simply traction in name, not in fact. But if the brace relieved symptoms, it did not, in many instances, prevent deformity; and as the prevention of deformity is an object only secondary in importance to the relief of pain, the treatment was in so far unsatisfactory. This deformity was usually flexion, occasionally combined with adduction, a deformity often increasing slowly without pain, or other evidence of greater activity of disease. If the deformity were reduced by traction in recumbency, it reappeared when ambulatory treatment, by the brace, was resumed. This flexion seemed to be in many instances simply an adaptation to the prevailing postures. When, for

example, the patient assumed the sitting position, the limb was flexed in spite of the brace, and as much of the time was passed in this attitude, its influence on the production of deformity seemed to be obvious. It was also apparent that the brace was not effective in relieving pain during the more acute exacerbations, even during recumbency with such traction as could be applied by the parents; nor when the children were brought in arms to the Clinic.

It is doubtless true that with proper nursing and proper care the apparatus might have been efficient, but the conditions were otherwise. Under these conditions it was found that acute symptoms might be relieved, or greatly modified, almost at once, by the application of a close-fitting short spica bandage extending from the middle of the thorax to the knee. Over this the brace was applied as before, making an apparatus which then combined splinting, traction and stilting. (Fig. 194.) This treatment was repeated in many instances, always with the same result. As the application of the plaster bandage was a somewhat tedious proceeding, it was often exchanged for a short Thomas splint worn beneath the pelvic band of the traction brace in the same manner. This fixation appliance not only relieved pain in the acute cases, but it also prevented the deformity, which was not checked by the traction brace alone.

FIG. 195.



The long inexpensive brace with solid upright showing the perineal bands and the adhesive plaster, as used in hospital practice.

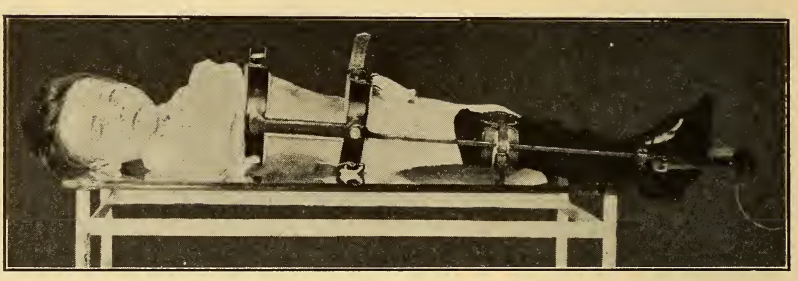
This combination of the Thomas brace and the traction hip splint, is the most effective mechanical means of relieving pain and preventing deformity, that can be employed in ambulatory treatment. It has, however, the disadvantage of requiring careful adjustment, and it obliges the patient to wear shoulder straps; in other words much care must be exercised to insure the comfortable adjustment of both appliances. Thus the next step was the combination of the two, even though the action was somewhat less effective. To the pelvic band of the traction brace a lateral thoracic bar was attached reaching upward in the axillary line to a point opposite the middle of the scapula, where it was joined to a metal band that encircled the chest, like that of the Phelps brace. When this was securely

fastened about the chest, the body and the limb were held in line by a long lateral brace; the pelvis was supported by the pelvic band and the joint received the additional protection that was assured by traction and stilting.[1] (Figs. 195 and 196.)

This brace and another form similar in principle, in which the upright of the thoracic attachment is fixed posteriorly to the pelvic band, are now in general use at the Hospital for Ruptured and Crippled. The efficiency of this brace may be still further increased by replacing the perineal bands by a metallic ring. This ring, which fits the upper extremity of the thigh closely, is attached to the upright at an inclination corresponding to the line of the groin. (Fig. 197.) (The Thomas ring described fully in connection with his knee splint.) It is a better support because it prevents antero-posterior motion within the pelvic band, which the perineal straps allow. The ring may be used as the only support or it may be combined with a perineal band on the opposite side. This is of advantage if there is a tendency toward adduction.

The apparatus is most satisfactory when the hollow upright of the

FIG. 196.



The long hip splint applied.

Taylor brace is used. This is light and strong and is provided with an arrangement for effective traction, but in hospital practice the upright is made of solid metal, and the traction is adjusted by simple straps. The metallic ring, besides providing better fixation, is a firm support that can not be disturbed by the patient. It is of course more difficult of adjustment, and it is not suited to the treatment of young children because of the difficulty in keeping it clean and dry.

The Thomas ring was first applied to a hip splint by Phelps. (Fig. 199.) He has always urged the advantages of fixation and traction, and his brace, of which that last described is simply a slight modification, is supplied with an arrangement for lateral traction. Practically speaking, this is a tape by which the lower third of the thigh is held in apposition to the upright. It hardly seems possible that appreciable lateral traction can be exerted on the joint by this means, and certainly none whatever if the metallic ring is properly fitted to the thigh. The simple straps do not afford as effective traction as the rack and pinion

[1] Ridlon at one time used a brace identical with this (Trans. Colorado Med. Soc., 1895) but Phelps appears to have first described a form of brace with a thoracic support in the axillary line.

nor is the brace, as usually constructed, sufficiently strong to bear the weight of the body without bending. It should be stated, however, that this form of brace is intended to be used with crutches rather than as a walking appliance.

Many objections to this attempt to combine the two methods of

FIG. 197.

The long brace with Thomas ring and extension upright, similar to Phelps' brace.

FIG. 198.

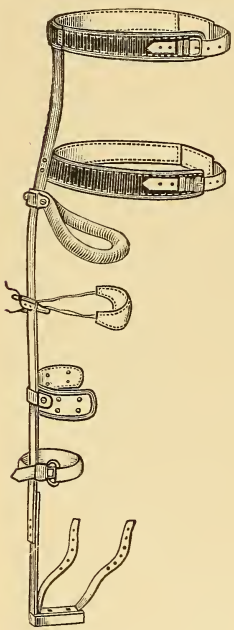
Rear view of brace.

treatment in one appliance have been urged by those who believe in the efficiency of the traction brace. For example, it is said that the splinting is ineffective because the movements of the trunk are transmitted to the joint, while this is not true of braces that do not extend

above the pelvis. In reply it may be stated that the traction part of the combined splint remains as effective as before; thus it follows that this suggestion is an acknowledgment of the fact that the theory of motion without friction is no longer tenable. As a matter of experience, however, it will be found that motion of the upper part of the trunk is absorbed, as it were, in the flexible lumbar region of the spine, before it reaches the joint. If, however, such motion or any motion causes discomfort or aggravates the symptoms, the patient should be confined in the recumbent posture until the acute phase of the disease is passed.

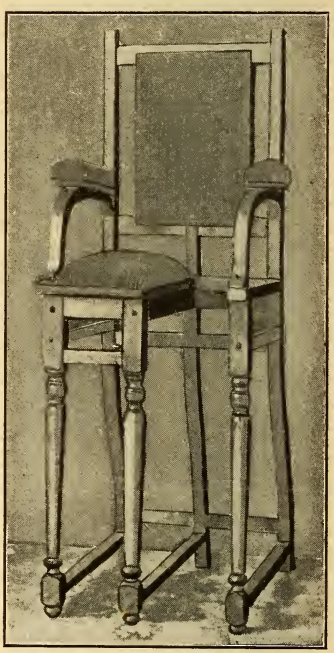
It is said that the brace is cumber-

FIG. 199.



The Phelps hip splint.

FIG. 200.



A chair to be used with the long hip splint. The patient sits upon the sound side, while the splinted half of the body remains in the extended position, the brace resting on the floor.

some, that the patient can not sit with comfort, and that it prevents normal activity.

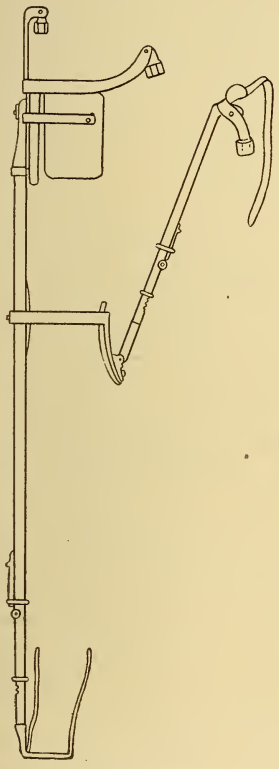
A long brace certainly weighs more than a short one, and if a brace prevents flexion at the hip and spine, it is evident that the patient can not sit with comfort in an ordinary chair.

As a matter of fact the patients themselves make little complaint of the brace, even when it has been substituted for an ordinary traction splint; while the greater restraint of activity is a favorable element of treatment, since children who do not suffer pain are much more likely to be too active than to be restrained by any form of appliance. These objections are trivial, if one is convinced that the dangerous and de-

forming disease that is under treatment may be more easily controlled and that the final result is likely to be better and to be more rapidly attained by this means than by another.

This form of brace is used exactly as is the ordinary traction brace. If deformity be present it is reduced by one or another of the methods

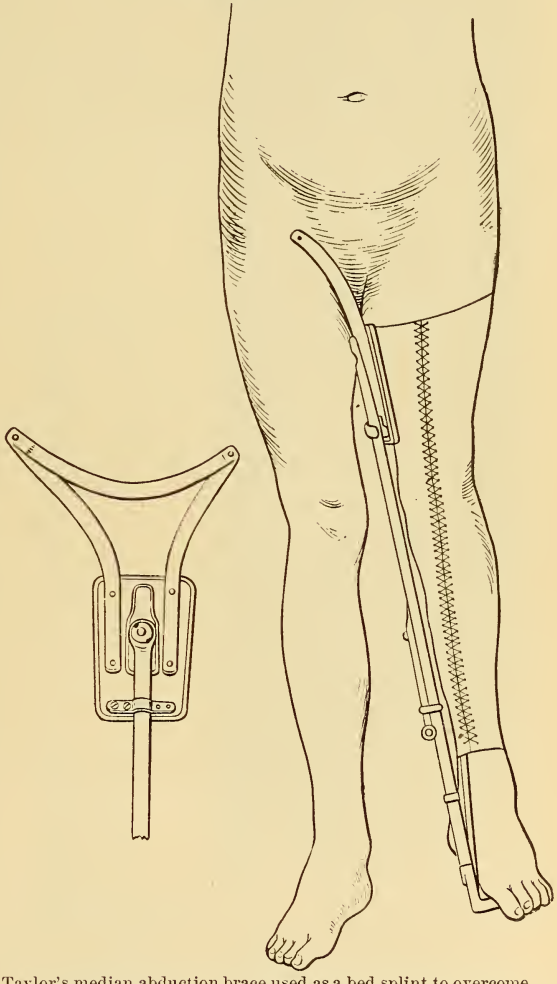
Fig. 201.



The Taylor hip splint as used by Taylor in the later years of his practice with but one perineal band.

The cut shows also an appliance for preventing or for correcting slight degrees of adduction, while the brace is in use as a walking appliance. The abduction bar is buckled about the upper extremity of the other thigh. (H. L. Taylor, Med. News, March 23, 1889.)

Fig. 202.



Taylor's median abduction brace used as a bed splint to overcome adduction by counter-pressure on the sound side.

that have been described. If the disease be acute, recumbency and traction are employed until this stage is passed.

When ambulation is resumed crutches may be employed for a time, but during the greater part of the treatment the brace is used as a walking appliance; as accurate splinting and as effective traction being employed during this period as circumstances will permit.

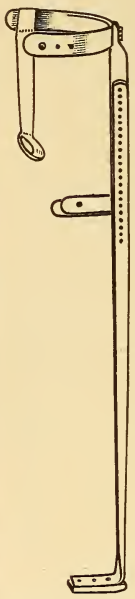
During the entire course of treatment, supervision of the patient, with the aim of adapting his activity to the local weakness, should be exercised, even though it may be less essential than when other apparatus is employed.

FIG. 203.

Modified brace to be worn during convalescence. Same patient as in Fig. 198. The thoracic part has been removed and the lower end of the stem has been made into a caliper, passing through the heel of the shoe. The stem is extended by means of the key until the heel is lifted slightly from the shoe, thus the hip is relieved from shock.

The impression that one might receive from descriptions of the treatment of hip disease, is that most cases begin acutely, or that when the patients are brought for treatment the disease is in an acute stage, or that deformity is present, so that preliminary recumbency is required. But each year the proportion of early cases is greater, cases in which there is no deformity and in which acute symptoms are absent. In such instances the hip splint may be applied without preliminary recumbency, and if the joint is fixed in the normal attitude and protected, a relatively rapid recovery without deformity and with a fair range of motion may be hoped for.

FIG. 204.



Judson's perineal crutch. This support suspended from the shoulders may be employed as a substitute for axillary crutches. It is also used as a convalescent splint in the treatment of hip disease.

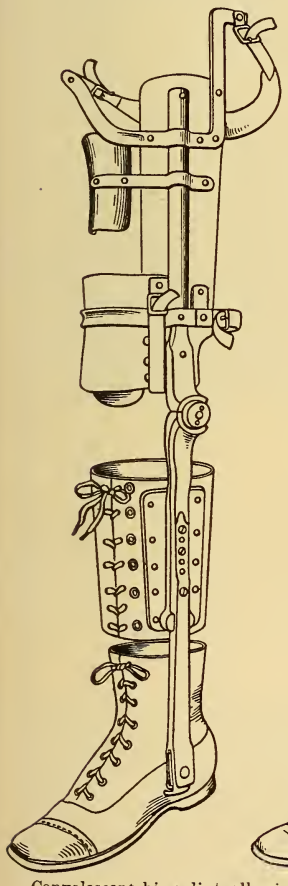
The Treatment of Hip Disease During the Stage of Recovery.—It is much easier to assure oneself that the disease is still active than to decide when it is cured. For the symptoms may have been quiescent for months or years even, under the protective treatment, and yet they may recur on the slightest provocation when this treatment has been discontinued.

To judge of the probable duration of the disease in a given case, one must consider its area, its quality and its complications. If, for example, the primary symptoms indicate that it is a limited focus of infection contained within the bone, rapid recovery, possibly in a year, may be expected; but in the ordinary type of disease in which the joint

has been invaded, repair can hardly be anticipated in less than three or four years.

Supposing the time to have elapsed in which a natural cure may have been accomplished; if the patient has had no symptoms of disease for a year or more; if there are no local signs of active disease, and if muscular spasm is absent, one may test the joint by removing the brace at night to ascertain the effect of simple motion without weight bearing. Such freedom will enable the patient to move the knee, which having been fixed in the extended position for so long usually remains stiff for a time, and in many instances several months may elapse before the full range of motion is regained.

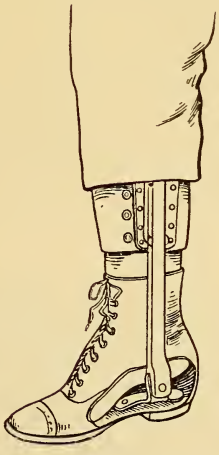
FIG. 205.



Convalescent hip splint, allowing motion at the knee. (TAYLOR.)

It is well also to remove the thoracic part of the brace, to allow the patient more mobility at the hip. At a later time the traction may be discontinued and the brace may be suspended from the shoulders to serve as a perineal crutch (Fig. 204); or it may be attached to the shoe and so adjusted as to be slightly longer than the limb, in order that direct concussion and pressure may be lessened. (Fig. 203.) Or a brace jointed at the knee, after the Taylor pattern may be employed.

FIG. 206.



This brace is so adjusted as to be slightly longer than the leg, so that the heel does not touch the bottom of the shoe. (Fig. 206.) Thus the weight is in great part supported on the perineal band. The weight of the brace may be in part supported and incidentally slight traction may be exerted by adhesive plaster applied above the knee. (Fig. 207.) The foot plate to which the upright is attached is shown in Figs. 206 and 208.

As the strain upon the part is increased, one watches carefully for the return of muscular spasm or for restriction of the range of motion. If the range of motion does not diminish, and if the deformity that may be present does not increase or does not appear if it be absent, the brace may be removed at intervals and finally discarded.

This stage of supervision even in favorable cases should be protracted, for no patient can be considered free from the danger of relapse for a long time after apparent cure. If there be firm bony anchylosis, as in exceptional cases, cure is assured; but if there be simply fibrous anchylosis, and particularly if there be upward displacement of the trochanter, a tendency to deformity remains, particularly toward flexion and adduction, even though the disease is cured. In such cases it is often

FIG. 207.

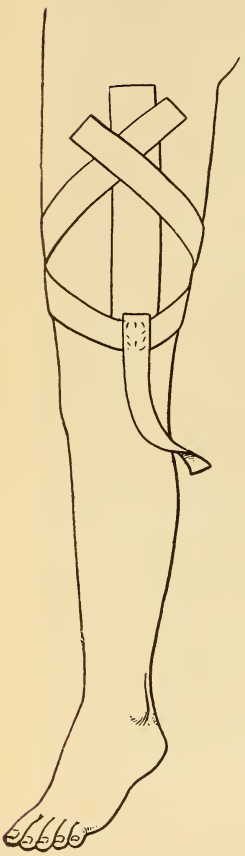
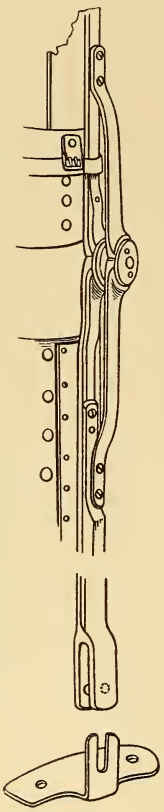
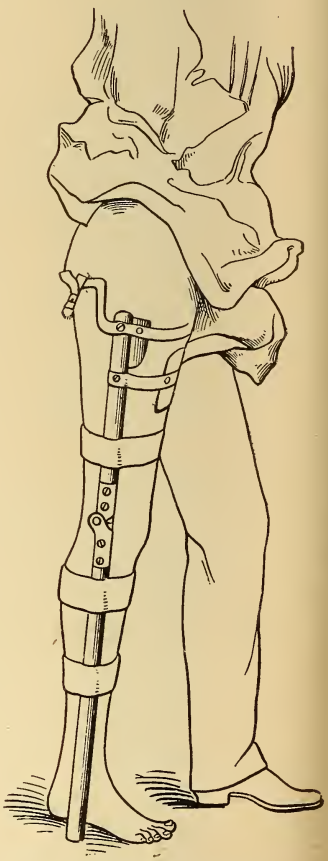


FIG. 208.



Details of the Taylor convalescent hip brace. Fig. 207, the adhesive plaster. Fig. 208, the foot plate showing the method of attachment.

FIG. 209.

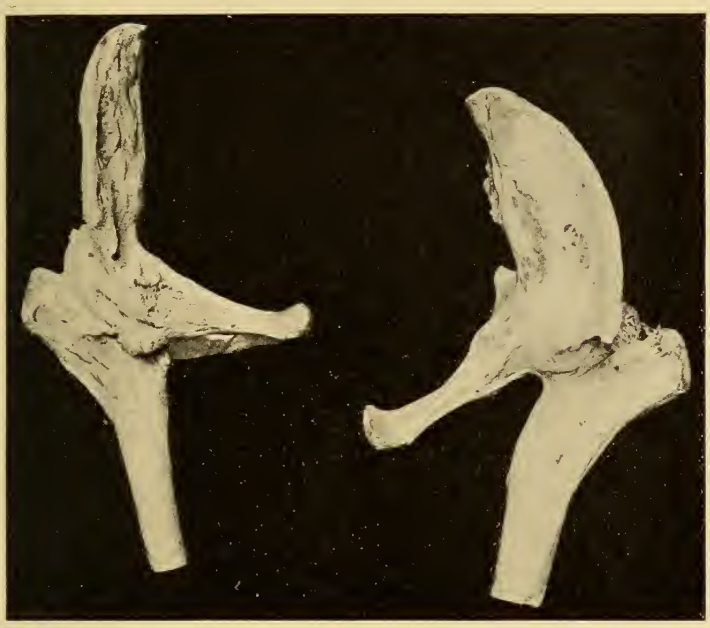


The action of the Taylor convalescent hip brace in removing direct pressure illustrated by a wooden model.

necessary to employ apparatus at intervals to reduce the deformity or to hold the limb in proper position until stability is assured. When the brace has been discarded, the patient should be trained to walk with equal steps, placing the limb, as far as is possible, on an equality with its fellow and adapting in like manner the stronger to the weaker member. This has an important influence in checking the tendency to

deformity and in modifying, or even concealing, the limp, a point to which Judson has repeatedly called attention.

FIG. 210.



Double hip disease terminating in bony anchylosis.

Double Hip Disease.

Ninety-five cases of bilateral hip disease were treated in the Hospital for Ruptured and Crippled during the ten years ending in 1899.

As a rule the second hip is affected some time after the symptoms of disease of the first have been apparent, but occasionally both joints are

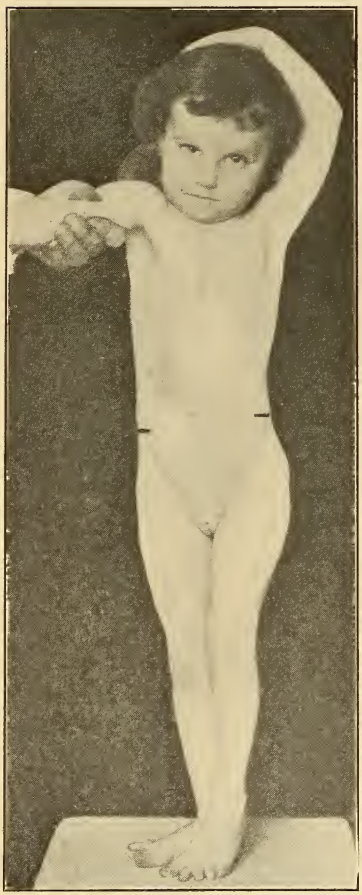
FIG. 211.

Left hip disease, showing swelling caused by abscess, also the absence of flexion deformity.

involved simultaneously. In most instances the symptoms are rather subacute, owing, very likely, to the fact that the activity of the patient is so restricted.

Treatment.—The treatment is similar in principle to that of the unilateral form. The patient during the greater part of the course of the disease must be confined in the recumbent position, although not necessarily in bed. The double Thomas hip splint is a convenient means of fixation. With this apparatus, extension by means of the weight and pulley may be employed, or the brace may be so modified as to provide independent traction. If the disease of one hip is acute and is attended by abscess formation, excision for the purpose of lessening the strain upon the patient and assuring a certain amount of motion in one limb may be advisable.

FIG. 212.



Untreated hip disease. Slight flexion and adduction (apparent shortening). The scar of a former abscess is seen on the outer aspect of the thigh.

If motion is greatly restricted in both joints locomotion unless crutches are used, is very difficult, as motion at the knees can supply only in small part the function of the hip joints.

Hip Disease Combined with Disease of Other Parts.

The most common combination is with Pott's disease. The two may be distinct primary foci, but occasionally it would appear that the disease of the hip is caused by the infection of an abscess, which, coming from the spine, remains for a long time in contact with the capsule of the joint. In five of the one hundred and fifty cases of disease of the hip joint of which the final results are reported by Gibney, Waterman and Reynolds (page 298), Pott's disease was a complication; in two instances preceding, and in three following, the disease at the hip. The combination of the two diseases makes the mechanical treatment difficult. Recumbency offers the best opportunity for the effective adjustment of apparatus when the disease of either part is acute. At a later period crutches may be employed, together with the necessary braces.

Hip Disease in Infancy.

Hip disease in infancy is far less common than in early childhood. It presents nothing of especial interest except that its effect upon the function of the joint and upon the development of the limb is usually more marked than in older subjects. (Fig. 184.) Tuberculous disease of this joint must be differentiated from infectious epiphysitis, in which prompt operative treatment is indicated.

Hip Disease in the Adult.

Hip disease in the adult may present the typical symptoms of the ordinary form, but it is usually of the more subacute type. Not infrequently it is a complication of tuberculosis of the lungs. The mechanical treatment is not difficult, but, in many instances, early excision may be advisable in order to bring about a rapid cure of the disease. This is far more important than in childhood, because few adults can afford the time required for the natural cure, and because in many instances, the general condition of the patient may demand relief from the depressing effects of the local disease, especially if it be complicated by suppuration.

The subacute form of tuberculous disease is often difficult to distinguish from arthritis deformans, if this be confined to the hip joint.

Abscess in Hip Disease.

It may be assumed that a limited collection of fluid product of the tuberculous process is present in nearly every case of hip disease in which the joint surfaces are actually involved. In many instances it remains within the joint. In a larger proportion of the cases the capsule is perforated, the fluid escapes and, if the quantity is sufficient to form an appreciable tumor, it is classed as an abscess. Such abscesses may be detected in about 50 per cent. of the cases that are treated under ordinary conditions.

In eight hundred and two final results collected from various sources, the percentage of abscess was as appears in the following table :

39 cases reported by Shaffer and Lovett[1]	69 per cent.
82 cases reported by Gibney[2]	60 "
390 cases reported by Bruns,[3] Tubingen	58 3 "
125 cases reported by Sasse,[4] Berlin	50 "
82 cases reported by Prendlsberger,[5] Vienna	51 "
84 cases in private practice, C. F. Taylor[6]	25 "

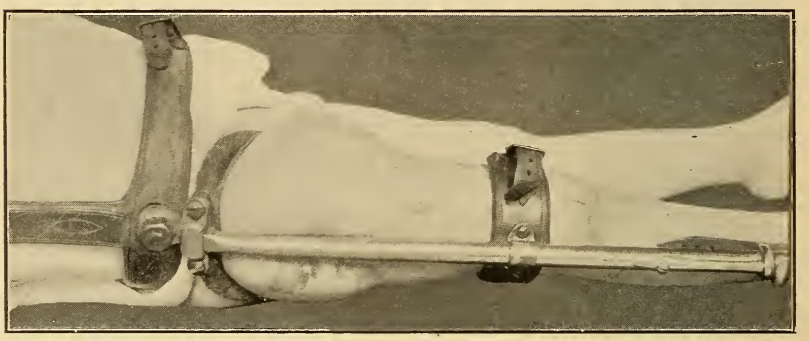
Most often the abscess first appears upon the outer and upper part of the thigh, in the space between the sartorius and tensor vaginæ femoris

[1] N. Y. Med. Journal, May 21, 1887.
[2] N. Y. Med. Record, March 2, 1878.
[3] Beit. zur klin. Chir., Bd. 30, 1895.
[4] Arbeit aus der Chir. Klinik der K. Univ. Berlin (Bergmann's Clinic), 1896.
[5] Behand der Gelenktuberculose und ihre Endresultate aus der Klinik Albert, Wien, 1894.
[6] Boston Med. and Surg. Jour., March 6, 1879.

muscles. From this point it may find its way to the inner or to the posterior surface of the limb, and if it increases in size it gradually sinks downward, guided somewhat in its direction by the layers of fascia that separate the muscles. In other instances it may be detected first on the inner side of the thigh, or it may form a tumor beneath the gluteal muscles; its situation being influenced by the point at which the capsule is ruptured. In rare instances, the acetabulum may be perforated and a pelvic abscess may be formed, or the pus may find its way into the pelvis along the course of the ilio-psoas muscle; and occasionally a pelvic abscess may exist which appears to have no direct communication with the joint.

The tuberculous abscess is a symptom and common accompaniment of hip disease, which, in cases treated under proper conditions, is not of great importance; and yet on the other hand, it is recognized as a dangerous complication. It is dangerous to life because of the profuse suppuration that may follow infection, and to function because of the

FIG. 213.



Abscess in hip disease. The brace is provided with the Thomas ring and with the ratchet extension.

adhesions and contractions that may result. This is evident in all statistics. It is clearly shown in those of Bruns. In this list the mortality in the non-suppurative cases was 23 per cent. and of the suppurative 52 per cent.

The Significance of Abscess.—If abscess appears early in the course of the disease, it usually indicates that it is of a destructive character and that the interior of the joint is involved, therefore perfect function is less likely to be preserved than in those cases in which the disease has been confined to the interior of the bone.

In certain instances abscess formation is preceded by an acute exacerbation of symptoms, by pain, by an increase of muscular spasm and consequent distortion, and often by an elevation of temperature. These acute symptoms subside and a fluctuating swelling appears. It may be inferred that the pain in such a case was due to the tension of the abscess within the capsule, and that the relief of pain followed perforation and the escape of the fluid.

In perhaps the larger proportion of cases, more especially those in which the joint has been protected, the formation of the abscess is not preceded by acute symptoms, such as have been described. Its appearance is long delayed, and but for the swelling that is apparent, its presence would not have been suspected.

As the progress of the disease is influenced by the strain and injury to which the part is subjected, so abscess, a symptom of disease, is more common in those cases in which early and efficient treatment has been neglected ; for the same reason its subsequent course is directly influenced by the protection that the diseased joint receives.

The danger from abscess is, of course, infection. Occasionally the abscess may become infected before an opening forms. Such infection may be inferred when the tissues about the abscess are hot and sensitive, and when fever is present; but as a rule, the abscess is sterile until the skin is perforated. When an opening forms there is danger of infection with pyogenic germs. If the abscess sac is small and if drainage is efficient, and especially if the communication with the joint has been occluded, infection is of slight consequence. But if before the opening has formed the abscess has perforated inter-muscular fascia and has extended between the layers of muscles in various directions, the infection of this area is likely to cause severe local and constitutional symptoms. The thigh becomes the seat of an infectious cellulitis, pockets of pus form, which cannot be properly drained ; hectic, emaciation and loss of appetite follow, and if the profuse discharge of pus persists, amyloid degeneration of the internal organs may result. Such patients are said to die of exhaustion, but the cause of the exhaustion is an infected abscess. At this stage the operation of excision of the joint is often performed. This operation removes the original source of the trouble, but the success of the procedure depends, in most instances, upon the efficiency of the drainage that is assured by the wide, deep incision and by the removal of the obstructing head of the bone. Thus when suppuration persists after excision and when the condition of the patient is not improved, amputation is logically indicated.

Treatment.—Admitting that abscess is a symptom whose importance stands in direct relation to the care that has been exercised in the treatment of the disease, and that in the better class of cases the danger from this source is slight, still it is also true that abscess is the chief cause of danger, and almost the only cause of death, in hip disease *per se*. One's views as to treatment are likely to be influenced by the class of cases with which he is most familiar. Some surgeons have advocated absolute non-interference with the symptomatic abscess on the ground that in many instances it finally disappears by spontaneous absorption ; while in other cases the long delay allows the communication with the joint to close, so that the danger of infection after an opening has formed, is slight. Finally, that the results after non-interference are better than those reported after operative treatment. Others insist that all collections of fluid of this character should be evacuated when they are discovered, because of the danger of infection before an open-

ing forms and because of the advantage gained by preventing burrowing of pus. There would be little to be said against this latter course were it not that infection is as common after operative treatment as when a spontaneous opening forms; the only advantage in favor of the artificial opening being that the cavity with which it communicates should be smaller than when the incision has been long delayed; but this is offset by the fact that at least 20 per cent. of abscesses disappear without treatment. In fact, as compared with indiscriminate incisions, when proper precaution and care cannot be assured, the let-alone treatment should be preferred.

It would appear, however, that the middle course, between the extremes, is the safest, and especially so as by far the larger number of patients must be treated under conditions that do not permit of proper care. In the outdoor department of the Hospital for Ruptured and Crippled abscesses are treated symptomatically. If a swelling appears but remains quiescent and causes no symptoms, it is not disturbed. If it enlarges, the tension of the fluid is relieved by aspiration, which may be repeated as required, compression, after the evacuation of the fluid, being applied by a pad and bandage. If the abscess is on the point of finding a spontaneous opening, or if its contents are of such a nature that aspiration is impossible, an incision is made and the proper dressings are applied; or, if the child lives at a distance from the hospital, the mother is instructed in the manner of dressing and as to the importance of cleanliness.

If the abscess is of large size, or if acute symptoms are present, the child is admitted to the hospital. Here the same general principle is followed, but at the present time the routine of treatment of non-infected abscess is free incision, that will allow complete evacuation of its contents. The abscess membrane is removed by gently rubbing with iodoformized gauze. If the opening in the capsule of the joint is exposed, this may be enlarged to permit of the evacuation of the products of disease within the joint, the wound is then closed with superficial and deep sutures, and a firm dressing is applied. This operation, if performed under aseptic precautions, causes no disturbance and it relieves nature from the burden of necrotic material which must be an obstacle to spontaneous absorption. In many instances the abscess is permanently cured, although if the condition that induced the abscess remains unchanged, fluid will again accumulate, and if so a spontaneous opening will form at the site of the operation. This operation is not a radical cure of the abscess or of the disease, it is simply a means of thorough evacuation for the purpose of accomplishing what the aspirator does only in part. If the abscess has become infected, its contents are completely removed, the wound is then packed with gauze and provision is made for efficient drainage.

In the treatment of abscesses the injection of iodoform emulsion, in connection with the aspiration, has been thoroughly tested. The results, as far as the disappearance of the abscess was concerned, were not as good as from simple aspiration; and as the procedure, being

somewhat of the nature of an operation, caused the patients some discomfort and anxiety, it was discontinued. From the clinical standpoint there is little evidence that these injections exercise any particular influence upon the disease, but theoretically, iodoform should lessen the infectiousness of the tuberculous fluid, and there appears to be no serious objection to its use.

The Treatment of Sinuses.—When the disease is in the active stage the sinuses that serve as drains should not be interfered with. And in the advanced cases when the disease is quiescent and when the tissues about the joint are of the peculiar, resistant, "porky" consistency, active measures, either for the purpose of closing sinuses, or for the correction of deformity, should be deferred. In many instances, however, sinuses persist as tuberculous fistulæ, serving no useful purpose. In this class the complete removal of the infected tissue by excision, or by thorough curetting, is the most effective remedy. The various applications of pure carbolic acid, solution of salicylic acid, iodoform emulsion, balsam of Peru and the like, are of some service, but thorough removal of the disease is the only radical treatment.

Exploratory Operations.—In certain instances exploratory operations may be indicated. When, for example, the pain and swelling indicate tension within the capsule, this may be relieved by an incision and the joint may be explored with the possibility of finding a localized focus of disease that may be removed.

The joint may be exposed by an antero-lateral incision, beginning one inch to the outer side of the anterior superior spine and extending downward about three inches. This exposes the line of junction between the tensor vaginæ femoris and the gluteus medius muscles. When these are separated from one another the anterior surface of the capsule of the joint is exposed. If more room is required the tensor vaginæ femoris muscle may be divided. The capsule is then incised in the line of the neck and through the incision the head of the bone may be extruded by rotating the limb outward and extending it. By this means the character of the disease may be ascertained and in certain instances localized foci in the neck or in the head of the bone may be removed. Thus the course of the disease may be shortened and cure even may be accomplished, as in two cases reported by Bloodgood.[1] Such an outcome is however most unusual.

Exploratory operations of this nature may be of especial value in the later stages of the disease, to ascertain the cause of long-continued suppuration, or of abnormal delay in repair, which may be due to detached or adherent fragments of necrosed bone within the joint. This point is illustrated by the statistics of sixty-one cases of hip disease treated by excision, by Poor.[2] In fifteen of these, loose bone was found in the joint, and in seven the head of the bone was detached.

In ninety-eight cases investigated by Lehman[3] at the Würzburg

[1] Bulletin Johns Hopkins Hospital, January, 1900.
[2] N. Y. Med. Jour., April 23, 1892.
[3] Inaug. diss. Würzburg, 1896.

clinic, sequestra were present in 20.4 per cent. and in 70 per cent. of eighty-eight cases treated by Riedel.[1]

An exploration of the joint by one familiar with surgical technique, should be free from danger. The wound may be closed or it may be drained, according to the indications. The operation is not indicated as a routine of practice, nor should it be expected by this means to cut short the course of the disease, but in certain instances it may be of great value.

Excision of the Hip.—At the Hospital for Ruptured and Crippled, the operation of excision is classed as a treatment of necessity in certain cases, usually those in which recovery under conservative treatment is considered very doubtful. For example, when there is progressive failure in health; when it is impossible to drain the joint effectively after infection; when there is evidence of extension of the disease to the shaft of the femur or to the pelvic cavity, or when other serious complications exist.

In certain instances the excision may follow an exploratory operation; in such cases the antero-lateral incision may be employed and the neck and head of the bone only may be removed. But in typical cases the operation is performed because of extensive disease and infected abscess, and in such instances the entire upper extremity of the bone to the trochanter minor is removed, ordinarily by a posterior incision, similar to that of Sayre. The knife entered above and in front of the trochanter is carried through the tissues close to its upper margin and the incision is prolonged down the posterior border of the femur to the trochanter minor. In certain instances an attempt is made to preserve the periosteum and the muscular attachments, but in the majority of the advanced cases, the soft parts are cut away as quickly as possible and the femur is divided with a chisel at the level of the trochanter minor. As much of the diseased tissue as is possible is cut away and the wound, together with the connecting suppurating tracts is packed with gauze. If the shaft of the femur is diseased its contents are removed and a counter opening for drainage is made. The operation is performed as quickly as possible and a very small amount of anæsthetic in employed, nitrous oxide gas having been used in many instances. The limb is supported by a plaster bandage or Thomas brace, and afterwards a hip splint is used for a time to prevent deformity.

The functional results after excision in this class of cases are not as good as those that are obtained when the operation has been performed at an earlier stage. If motion continues free, the joint is usually insecure. In many instances there is upward displacement of the shaft of the femur upon the ilium with consequent flexion and adduction deformity, while in a third class of cases a movable joint of sufficient strength may be preserved. The ultimate shortening is considerably greater than after conservative treatment. This is accounted for by the upward displacement of the femur and by the removal of the two epiphyses of its upper extremity.

[1] Centb. f. Chir., 1893, Bd. XX., Nos. 7 and 8.

In the twelve years, 1888 to 1899 inclusive, 149 operations of excision were performed at the Hospital for Ruptured and Crippled. During this time 1,283 cases of hip disease were treated in the wards and 1,870 new cases were recorded in the out-patient department. Thus the operation was performed in 11.6 per cent. of those in the hospital, but the relative frequency of the operation in the entire number of patients under treatment, was considerably less than this.

One hundred and twenty-one of these operations of excision, or those performed prior to 1897, have been carefully analyzed by Townsend.[1] The 121 operations were performed on 119 patients, in two instances both hips having been operated upon. In 113, abscesses or sinuses were present, in most instances infected. In 5 cases the spine was involved as well as the hip; in 2 instances the knee, in 2 the tarsus, in 3 the ilium. In 24 cases the anterior incision was employed, in 97 the posterior. In 18 instances the acetabulum was seriously diseased and in 10 osteomyelitis of the shaft of the femur was present. This indicates the character of the disease in the cases operated upon.

In 99 of the 119 cases the later results of the operation were ascertained. Of these 52 were dead and 47 were living. Of the 52 deaths 9 were due directly to the operation, shock; 28 were caused by exhaustion; 9 by tuberculous meningitis; 7 by other causes. Thirty-seven deaths occurred within six months and 10 others within one year of the operation. Of the 47 patients living at the time of the investigation 26 were cured. Of the remaining number about one half were in poor condition so that recovery could not be expected. It is evident that in a large proportion of the cases the operation was unsuccessful as a life-saving measure since suppuration persisted.

The functional results in these cases are shown in the table on the following page.

Lovett[2] has reported the results of 50 excisions in a similar class of cases at the Boston Children's Hospital, 1877 to 1895. The number of patients actually treated in the wards of the hospital is not stated, but 1,100 cases were recorded as having been under treatment during this time, a percentage of excisions of 4.5 of the total number. In eight of the cases osteomyelitis of the femur was present and in 15 the acetabulum was perforated. The ultimate mortality was about 50 per cent.

Poor[3] has reported the results in 65 cases operated upon at St. Mary's Hospital, New York, with a final mortality of about 43 per cent. In 21 cases osteomyelitis of the shaft of the femur was present. In 11 cases there was perforation of the acetabulum and in 9 of these the opening communicated with an intra-pelvic abscess.

These statistics are quoted to illustrate the relative efficiency of late excision. The extent of the lesions in some of the cases shows that recovery would have been impossible without operation, and its failure to relieve the symptoms in so many instances is sufficient evidence that it was postponed too long. Under proper conditions for treatment ex-

[1] Medical News, June 26, 1897.
[2] Trans. Am. Ortho. Ass'n, Vol. X.
[3] N. Y. Med. Jour., April 23, 1892.

cision of the hip is almost never required, but in hospital practice it would seem that it should be performed oftener and at an earlier stage of the disease.

TABLE SHOWING SHORTENING, MOTION, NUMBER OF SINUSES PRESENT, AND ANGLE OF GREATEST EXTENSION IN 47 CASES OF EXCISION. (TOWNSEND.)

No.	Time since operation.	General Condition.	Sinuses present.	Angle of greatest extension.	Motion in degrees.	Shortening in inches.
1	6¾ years.	Good	3	150	0	2½
2	6¼ "	Fair	1	135	0	4
3	6 "	Good	0	180	100	3
4	5¾ "	"	0	180	35	3
5	5¾ "	Fair	0	145	10	4
6	5½ "	Good	1	165	0	1¼
7	5 "	"	0	155	5	2½
8	4¾ "	"	3	160	0	2½
9	4½ "	"	0	160	0	2¾
10	4¼ "	"	0	165	0	1¼
11	4 "	"	0	150	0	1½
12	4 "	Poor	4	.....	0	1½
13	3½ "	Good	0	155	0	1½
14	3½ "	"	0	160	30	1
15	3 "	Poor	1	165	0	¾
16	2 "	Fair	2	145	30	¾
17	2 "	Good				
18	2 "	Fair	1	170	0	½
19	2 "	Good	0	150	0	3
20	1¾ "	"	0	175	.....	½
21	1¾ "	"	0	165	30	½
22	1½ "	"	0	150	0	1
23	1½ "	"	0	150	0	1½
24	1¼ "	"	1	180	0	½
25	1¼ "	Fair	6	175	15	1
26	1 "	Poor	2	165	0	2½
27	1 "	Good	0	170	0	1½
28	1 "	"	0	155	0	1
29	1 "	"	0	175	0	½
30	1 "	Poor	0	180	10	1¼
31	11 months.	"	3	170	0	¼
32	10 "	"	0	180	40	1¼
33	10 "	Good	3	165	0	½
34	10 "	"	0	160	0	½
35	10 "	"	1	165	0	1
36	10 "	Poor	1	160	0	¼
37	10 "	Good	3	155	10	1¼
38	9 "	"	1	.....	0	½
39	9 "	"	0	.....	.....	½
40	9 "	Poor	1	170	0	½
41	9 "	Fair	3	.....	.....	1
42	8 "	Good	0	180	130	½
43	8 "	"	0	180	.....	¼
44	8 "	Poor	1	165	10	¾
45	7 "	"				
46	7 "	Good	0	180	10	1¼
47	7 "	"	0	160	70	¼

Amputation.—Amputation at the hip should follow excision when suppuration persists and when the condition of the patient does not improve, provided the internal organs are not hopelessly diseased.

The operation of amputation after complete excision is a simple procedure and it should not be attended with great danger.

Reduction of Deformity in Resistant Cases.—The various methods of reducing deformity during the active stages of the disease have been described, and the importance of preventing deformity throughout the entire course of treatment has been insisted on. At the present time, for one reason or another, deformity from this cause is very common, either because its importance is not appreciated or because it is considered as a necessary concomitant of the disease, treated by apparatus, as it is in the natural cure. At all events in many instances it is allowed to persist until the accommodative changes about the diseased joint have so fixed the limb in the deformed position that greater correcting force is required than can be applied by the weight and pulley or by other method of traction.

FIG. 214.

Extreme deformity after hip disease. (See Figs. 215, 216.) Showing the attitude in standing before operation.

In this class of cases, in which the muscles are structurally shortened and in part transformed to fibrous tissue, and in which the anterior wall of the capsule has become retracted and it may be adherent to the surrounding parts, forcible reduction under anæsthesia, or osteotomy, may be required. If the disease is quiescent, or cured; if the head of the femur or what remains of it is in the normal position, and if a fair range of motion remains, gradual forcible reduction after division of the bands of fascia or the muscles that hold the limb in the deformed position, is advisable. After reduction of the deformity in one or more sittings, the limb must be fixed in a long spica bandage and held in this position by this or other fixative appliance, until the tendency to deformity has been overcome.

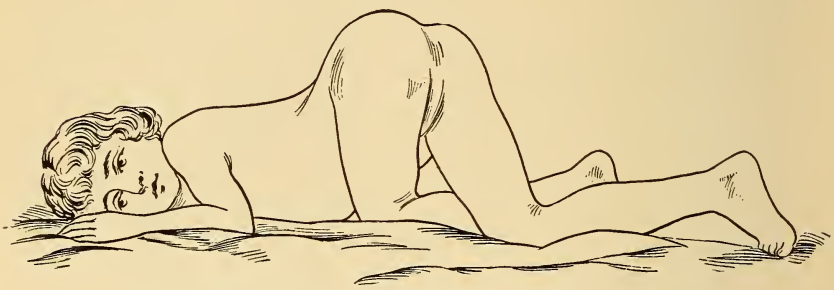
This method of reducing deformity of the more or less resistant type has been performed in 329 instances at the Hospital for Ruptured and Crippled during the past ten years, with but one death; from fat embolism.

The Correction of Deformity by Femoral Osteotomy.—If the deformity is fixed by bony anchylosis or by firm fibrous adhesions within the

joint, or if it is feared that violence may stimulate dormant disease; or if there is such a degree of upward displacement of the femur upon the pelvis that the deformity is likely to recur after replacement, it is better to correct the deformity by an osteotomy of the femur.

The patient having been prepared for operation, is turned upon the side and a sandbag is placed between the thighs. A small osteotome about the shape of a lead pencil, of which one extremity is flattened to a cutting edge (Vance's instrument), is pushed directly through the soft parts to the femur at a point about two inches below the apex of the trochanter. It is turned until its cutting edge is at a right angle to the shaft and it is then driven through the cortical substance of the bone. When it has penetrated at one point it is withdrawn, and adjoining portions are cut until about half the circumference is divided, when with slight force the bone may be fractured. If the deformity is of long standing, division of the contracted tissues in the adductor region and below the anterior superior spine, may be required. The

FIG. 215.



The favorite attitude in recumbency. (See Fig. 214.)

limb is then drawn down to complete extension and moderate abduction and the body and limb are encased in a plaster of Paris spica bandage which should remain in position for several months, although the patient may be allowed to bear weight on the limb in a few weeks after the operation.

The advantages of the subcutaneous method are simplicity and freedom from danger. No dressings are required, except a pad of gauze over the minute opening, thus the limb may be firmly held by the plaster bandage. If there is anchylosis between the femur and the pelvis no support will be required after the bone has united, but if there is motion in the joint, some fixative appliance should be employed for a time, to prevent recurrence of a part of the deformity.

During the past ten years this operation has been performed 147 times without a mishap, at the Hospital for Ruptured and Crippled. It is especially valuable as a means of correction of extreme and disabling deformity.

Prognosis. MORTALITY.—The direct mortality of hip disease is due almost entirely to the immediate or remote effects of abscess.

This is illustrated by the statistics of Bruns in which the mortality from all causes of the non-suppurative cases was 23 per cent. as compared with 52 per cent. in those in which suppuration was present.

The mortality among the patients treated at many of the German clinics is much higher than in the corresponding class in this country.

At Tübingen, according to Wagner,[1] it was 40 per cent.

At Kiel, according to Mummelthy, it was 48.59 per cent. in non-operative cases and 53.96 per cent. in operative cases.

At Marburg, according to Marsch, it was 35 per cent. in non-operative cases and 40.4 per cent. in operative cases.

At Heidelberg, according to Huismans,[2] it was 46.6 per cent. in non-operative cases and 58 per cent. in operative cases.

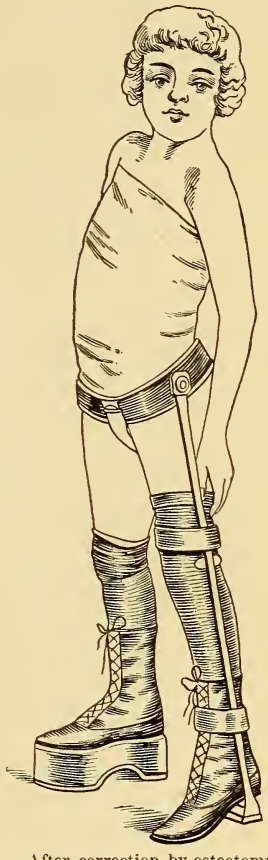
At Zurich, according to Pedolin,[3] it was 37.7 per cent. in non-operative cases and 54 per cent. in operative cases.

At Vienna, according to Prendlsburger,[4] it was 17 per cent. in all classes.

In a total of 636 cases treated by conservative methods by Rabl, 1859 to 1894, definite results were ascertained in 519.[5] 335 were hospital cases. Of these 216 were cured, 64.4 per cent. 70 died, 20.8 per cent., and 49, 14.4 per cent., were still under treatment. 184 were treated as out-patients; of these 132 were cured, 71.5 per cent.; 35 died, 19.2 per cent., and 17, 9.2 per cent., remained under treatment.

In 288 cases treated at the Hospital for Ruptured and Crippled, New York, reported by Gibney,[6] the death rate was 12.5 per cent.

FIG. 216.



After correction by osteotomy and division of the contracted tissues. See Figs. 214, 215. (GIBNEY.)

In private practice the statistical reports of final results show the death rate to be extremely small. C. F. Taylor,[7] 94 cases, including 24 in which suppuration was presented, 3 deaths. L. A. Sayre,[8] 212 cases, 5 deaths. Lorenz,[9] 60 cases with 3 deaths.

In the clinics of this country the death rate has been estimated to

[1] Beit. z. klin. Chir., Bd. 13, 1895.
[2] Quoted by Binder, Zeits. f. Orthop. Chir., Bd. 7, H. 2 and 3, 1889.
[3] Centb. f. Chir., No. 30, July 25, 1896.
[4] Loc. cit.
[5] Zur Conserv. Behand. der tuberculosen Knochen und Gelenksleiden, J. Rabl, Leipzig und Wein, 1895.
[6] N. Y. Med. Jour., July–August, 1877.
[7] Boston Med. and Surg. Jour., March 6, 1879.
[8] N. Y. Jour., April 30, 1892.
[9] Wiener Klinik, 10 and 11, 1892.

be from 10 to 15 per cent., a rate of mortality much lower than that reported from those abroad. This is accounted for, in part, by the fact that patients are of a better class and in part because they receive earlier and more efficient mechanical protection.

The causes of death, according to Wagner's statistics of 124 cases, were as follows:

Hip disease	35
General tuberculosis	37
Tuberculous meningitis	13
Tuberculosis of the lungs	11
Acute miliary tuberculosis	5
Amyloid degeneration	8
Septic infection	12
Intercurrent disease	3
	124

Thirty per cent. of the deaths occurred in the first year of the disease, 26 per cent. in the second year and 20.4 per cent. in the third year.

The percentage of recovery was 65 per cent. of those in the first decade of life, 56 per cent. of those in the second and but 28 per cent. of those in the third decade.

The causes of death in 50 cases among 778 patients treated at the N. Y. Orthopædic Dispensary and Hospital during the years 1877 to 1882 were:[1]

Tuberculous meningitis	20
Amyloid degeneration	5
Exhaustion	3
Tuberculosis of the lungs	3
Tuberculous peritonitis	1
Septicæmia	1
Convulsions	1
Unknown	16
	50

Of 96 deaths recorded at the Alexandra Hospital, London (a mortality of about 26 per cent. of the cases treated), the causes were

Tuberculous meningitis	16.7	per cent.
Albuminuria and dropsy	20.8	"
Tuberculosis of the lungs	8.3	"
Exhaustion	9.4	"
Erysipelas and pyæmia	3.1	"
After operation	9.4	"
Intercurrent diseases	7.3	"
Unknown	25.0	"
	100.0	"

The direct mortality of hip disease should include all deaths due to operation, those caused by exhaustion and by amyloid degeneration, which is almost always the result of profuse suppuration secondary to pyogenic infection. While tuberculous meningitis or other forms of tuberculous disease may have been due to new infection or may have been caused by infection from the primary focus which preceded the

[1] Shaffer and Lovett, N. Y. Med. Jour., May 21, 1887.

tuberculosis of the hip, although exhausting local disease by lowering the vital resistance would still be an indirect cause of death.

It is believed that operative interference is sometimes the direct cause of tuberculous meningitis, and it is of interest in this connection to note that 20 of 50 deaths, or rather of 34, in which the cause of death was known, 58 per cent. were due to this complication among the cases treated at the New York Orthopædic Dispensary and Hospital where no operations were performed.[1] While of 52 deaths in a total of 99 cases treated at the Hospital for Ruptured and Crippled, in which excision was performed, but 9 were caused by tuberculous meningitis.[2]

The normal death rate among cases under fair hygienic conditions is illustrated by statistics from the Hospital for Ruptured and Crippled, at a time when no operative or mechanical treatment was employed.[3] This was 12.5 per cent.: 4.5 per cent. from exhaustion, 4.5 per cent. from amyloid degeneration, 1.75 per cent. from tuberculous meningitis, 1.75 per cent. from intercurrent diseases.

Thus nearly 75 per cent. of the deaths were due more or less directly to suppuration.

FUNCTIONAL RESULTS.—In a certain proportion of cases perfect function may be retained, the proportion depending upon the extent of the disease, and upon the timeliness and efficiency of the treatment.

In a total of two hundred and eighty cases from the private practice of Dr. L. A. Sayre,[4] in which the final results were known, seventy-three or 26 per cent. recovered with perfect motion, and one hundred and twenty or 42 per cent. retained good motion. These results are extraordinarily good, very much better than any others that have been reported, and of course far better than may be expected in the ordinary class of cases.

The effect of mechanical treatment and of the various measures employed for the correction of deformity is well illustrated in two series of ultimate results in cases treated at the Hospital for Ruptured and Crippled, reported by Gibney.[5] In the first series of 80 cases no mechanical or operative measures were employed, the treatment being simply hygienic and symptomatic; the results therefore represent natural cure under proper supervision. The duration of the disease was 3 years in twenty-three, 3 to 6 years in twenty-eight, 6 to 10 years in sixteen and 15 years in one case.

In thirty-five cases the shortening was two inches or more, and in nearly every case there was more or less deformity, viz.:

In	2	there was flexion to	90	degrees.
In	3	" "	110	"
In	3	" "	120	"
In	19	" "	135	"
In	19	" "	145	"
In	18	" "	150	"
In	11	" "	160–170	"

[1] Shaffer and Lovett, N. Y. Med. Jour., May 21, 1887.
[2] Townsend, Med. News, June 26, 1896.
[3] Gibney, N. Y. Med. Record, March 2, 1878.
[4] N. Y. Med. Jour., April 30, 1892.
[5] Loc. cit.

In 4 no estimate was made. Distortions other than flexion are not specified.

In 12 instances motion was retained of from 15 to 90 degrees.

In the second series[1] of one hundred and seven cured cases, mechanical and operative treatment was employed although the protection assured was in many instances far from efficient. In many of these cases the disease was in an advanced stage, and deformity was present in more than half of the number when treatment was begun, and yet all of them recovered without marked flexion and presumably without adduction, as this deformity is not mentioned.

47 had no flexion.
30 " flexion to 170 to 180 degrees.
20 " " 160 " 170 "
10 " " 150 " 160 "

Perfect motion was retained in 13.
Good motion was retained in 22
Limited motion was retained in 41.
In 31 there was anchylosis.

In 69 cases the shortening was one inch or less, 35 having no shortening. In 38 it was more than one inch.

As has been stated, the mechanical treatment was not sufficiently effective to prevent deformity and to attain these results osteotomy with or without division of contracted tissues was performed in 19 cases; forcible correction with or without tenotomy in 30 cases and in 4 cases the joint was excised.

If the joint has been actually invaded by disease so that a part of its articulating surface has been destroyed, motion must be impeded both in area and quality. In such cases the joint is usually somewhat weakened although not to the extent of interfering seriously with the ability of the patient. In many instances, discomfort in damp weather or pain on over-exertion, is experienced, symptoms similar to those complained of by rheumatic subjects.

Simple shortening, due to retardation of growth, unaccompanied by deformity, is of comparatively little importance. Anchylosis in a symmetrical position insures a strong and useful limb, the flexibility of the lumbar region compensating for the loss of motion at the joint. In such cases the disability may be very slight, and the effect of the loss of motion may be more apparent in the sitting than in the erect posture, for the patient must, as it were, sit upon his back, an attitude which perceptibly reduces the sitting height.

Flexion, if it be slight does not cause disability, but flexion of more than 30 degrees increases the lumbar lordosis and makes the buttock prominent, the deformity so characteristic of the natural cure. (Fig. 166.) Great flexion, for example of 60 or 90 degrees, causes an exaggerated lordosis which is almost always a source of pain or discomfort to a patient who is obliged to stand much of the time.

Abduction is of no importance unless it be considerable. It serves in most instances as a compensation for actual shortening of the limb.

[1] Gibney, Waterman and Reynolds, Trans. Am. Orth. Ass'n, Vol. XI., 1898.

Adduction, on the other hand, which necessitates an upward tilting of the pelvis in order to restore the parallelism of the limbs, is the most disastrous of all the distortions since it causes a practical shortening often greater than that due to the destructive effects of the disease.

DEFORMITIES OF OTHER PARTS, CAUSED BY HIP DISEASE.—Deformities of other parts are sometimes observed as secondary results of hip disease, most often in cases that have not received proper treatment. In the spine an exaggerated LORDOSIS as a compensation for flexion is not uncommon, and LATERAL CURVATURE may follow distortion of the pelvis caused by adduction. In the limb, KNOCK KNEE may follow persistent adduction of the thigh or it may be an effect of laxity of the ligaments, without such distortion. Another deformity is GENU RECURVATUM. This is apparently caused by long-continued disuse of the limb and by the use of apparatus in which the knee has not been properly supported. It is supposed to be one of the effects of traction, but it is also observed in cases in which traction has never been employed. In cases in which the muscular atrophy that follows limited motion and long-continued disuse, is great, LAXITY OF THE LIGAMENTS of the knee joint is common. A slight degree of EQUINUS with accompanying exaggeration of the arch, is not uncommon among patients who have been treated by the traction apparatus, in which the foot is pendant and in which the toes are often inclined downward to guide the brace in walking. Practically speaking, all these secondary deformities may be avoided by proper supervision of the patient during the period of treatment.

As a rule, patients who have recovered from hip disease finally discard all apparatus, or at most use only a cane as a support, and many prefer to walk habitually on the toe rather than to equalize the length of the limbs by a high shoe.

In conclusion it may be stated that by far the larger number of this class, having accommodated themselves to whatever weakness and distortion may be present are able to undertake the ordinary occupations of life. Of the patients cured at the New York Orthopædic Dispensary and Hospital in the report already referred to, in whom the final results as regards motion and symmetry were certainly not above the average, it is stated that there was not a single individual who was incapacitated from doing a full day's work at his or her trade or occupation. None used crutches and but one used a cane.

CHAPTER VIII.

NON-TUBERCULOUS AFFECTIONS OF THE HIP JOINT.

Traumatisms at the Hip.

It is probable that injury at the hip joint, caused by falls or strains, may induce congestion about the epiphyseal cartilage of the head of the femur and consequent discomfort, a variety of the so-called growing pain. In this class of cases there may be a limp and restriction of motion that may disappear in a few days or that may recur from time to time. If the injury is more severe there may be local sensitiveness and even swelling—synovitis. This congestion may be a predisposing cause of tuberculous disease and it is probable that cases of this type are sometimes mistaken for hip disease and go to swell the number of perfect functional results that are attained by one or another system of treatment.

Treatment.—All cases of this class require careful treatment and supervision. Strains or other injuries, in young children, are best treated by a supporting bandage and by rest in bed until the symptoms disappear. If the sensitive condition persists, protective treatment by a brace, preferably the ordinary traction hip splint, should be employed, the diagnosis being reserved until it is made clear by the progress of the case. Chronic synovitis of the hip joint, especially in the adolescent or adult, unless it be a result of severe injury, is usually tuberculous in character.

Fracture of the neck of the femur in childhood will be considered in connection with coxa vara.

Acute Infectious Arthritis; Acute Epiphysitis at the Hip.

Acute epiphysitis, caused by infection with pyogenic germs, is not uncommon in infancy and early childhood and it often passes as a form of acute tuberculous disease. In fifty-two cases in which but a single joint was involved the hip was affected in twenty-six.[1] In some instances it is caused apparently by injury, in others it is secondary to an infected wound and not uncommonly it follows pneumonia or one of the exanthemata. (See page 211.)

Symptoms.—The symptoms are of sudden onset, accompanied usually by high fever and prostration. The hip becomes swollen, hot, and sensitive both to motion and pressure.

Treatment.—The treatment is early and free incision and efficient drainage, the limb being afterwards supported by some form of splint. The suppuration ordinarily persists for several months; the epiphysis is usually destroyed and in consequence the joint becomes somewhat

[1] Townsend, Am. Jour. Med. Sci., Jan., 1890.

loose and flail-like. (Fig. 217.) Many of these cases seen in later years, but for the history and the scars about the joint, might be mistaken for congenital dislocation. In certain instances the symptoms are less acute and the diagnosis from tuberculous disease can be made positively only after a bacteriological examination of the fluid that may be removed from the joint by aspiration.

In the class of cases in which the disease is confined to one joint and in which the shaft of the bone is not involved, the prognosis is good if the pus is thoroughly evacuated. In twelve cases treated at the Hospital for Ruptured and Crippled there were three deaths.[1] The prognosis as to function under these conditions is much better than in tuberculous disease.

After recovery, the joint should be supported for a time, to prevent upward displacement.

In the forms of arthritis that may complicate infectious diseases several joints are usually involved and the affection is often subacute in character.

Spontaneous Dislocation of the Hip. —If the hip joint becomes distended with fluid the capsule may be ruptured and sudden displacement may occur.

Degez,[2] has collected from literature 79 cases of this character. The displacement occurred in the course of the following diseases:

Typhoid fever	32
Rheumatism	24
Scarlatina	13
Variola	3
Gonorrhœal arthritis	3
Grippe	2
Erysipelas	1
Eruptive fever	1

Fig. 217.

The effect of acute epiphysitis of the right hip at three months of age. The scar is shown.

Such accidents may be guarded against by preventing flexion and adduction of the limb and by an evacuation of the fluid that distends the joint. The femur may be replaced if an opportunity is offered, before it has become fixed by adhesions and contractions. Once replaced it must be held in proper position for a time, by apparatus.

Extra-Articular Disease.

Occasionally tuberculous disease, or other form of destructive ostitis, may begin in the neighborhood of the trochanter major. The symptoms are local pain, sensitiveness and swelling of the soft parts, and thickening and irregularity of the underlying bone.

[1] Townsend, loc. cit. [2] Revue d'Orthopédie, January 1, 1899.

The treatment is prompt removal of the focus of disease, before the joint or the shaft of the femur has become involved.

Malignant Disease of the Hip Joint.

Carcinoma of the upper extremity of the femur is almost always secondary to a primary tumor of another part of the body. Sarcoma is far less frequent in this situation than at the knee. The character of the disease soon becomes evident in the general enlargement of the upper extremity of the thigh, but in the early stage diagnosis can be made only by means of the X-ray or by exploratory incision.

Cysts of the Femur.

In extremely rare instances cysts, caused apparently by inclusion of a displaced portion of epiphyseal cartilage, may cause enlargement, weakening and deformity of the upper extremity of the femur. In one case, treated at the Hospital for Ruptured and Crippled, discomfort, limp and outward bowing of the femur in a boy thirteen years of age, was found on examination to be caused by a cyst of this character. Relief followed its removal.

Gluteal Bursitis.—An enlargement of one of the bursæ lying beneath the gluteal muscles, may cause a rounded, fluctuating swelling in the buttock. It may be painful to pressure and it usually causes a limp, and some discomfort on motion, dependent upon the degree of inflammation that may be present. Occasionally the bursitis may be caused by injury, but in most instances it is the result of tuberculous infection. The bursa may communicate with a diseased hip joint, but usually it is a distinct and primary inflammation.

Ilio-Psoas Bursitis.—This causes a distinct swelling on the upper and inner aspect of the thigh. It is usually accompanied by slight flexion, abduction and outward rotation of the limb, an attitude that relieves the tension on the sensitive part. Zuelzer has collected from literature 45 cases of gluteal and 15 of ilio-psoas bursitis. This illustrates the relative frequency of the two affections.[1]

Simple bursitis may be distinguished from disease of the joint by the absence of characteristic muscular spasm and general limitation of motion.

Treatment.—Chronic disease of bursæ is usually tuberculous in character, thus radical removal of the sac is advisable. Aspiration and injection of carbolic acid or iodoform emulsion may be employed as primary measures.

ARTHRITIS DEFORMANS.

Osteo-arthritis of the Hip Joint.

Osteo-arthritis, in certain instances, may be confined to the hip joint. In this form it is an affection of adult life or old age. It is character-

[1] Deutsch Zeits. f. Chir., Bd. 50, H. 1 and 2.

ized by disappearance of the cartilage covering the head of the femur and by an eburnation and progressive destruction, or wearing away, of the underlying bone. At the same time there is formation of ecchondroses, about the margin of the femur and the acetabulum, which become ossified into irregular masses of bone. In the early stage of the affection the fluid within the joint may be increased in amount, but later it is diminished in quantity and changed in quality as the synovial membrane becomes transformed in part to fibrous tissue. (See p. 212.)

Symptoms.—The early symptoms are neuralgic pain in the limb, "sciatic rheumatism" and sensitiveness about the joint so that the patient lies habitually on the other side. The movements of the joint become somewhat restricted and, in certain instances, creaking sounds are apparent to the patient. In the advanced stages of the disease, there is marked thickening about the trochanter which is usually displaced upward, owing to the progressive changes in the head and neck of the femur; and the limb is distorted in flexion and adduction, symptoms that, but for the history, might be mistaken for the results of fracture of the neck of the femur. While in the earlier period of the disease the limp, the pain and restriction of motion with the attendant atrophy may simulate very closely tuberculous disease of a subacute type.

Treatment.—In the class of cases in which the disease is confined to a single joint and in which the symptoms are dependent upon the destruction of the joint, protective treatment is indicated.

If deformity be present it should be reduced by traction and rest in bed. Afterwards the symptoms may be relieved by the use of a hip splint (Fig. 205) that will remove the weight, and limit the range of motion somewhat. In most instances such treatment is not feasible, but the use of a firm flannel spica bandage, combined with the application of cautery, from time to time, adds to the comfort of the patient.

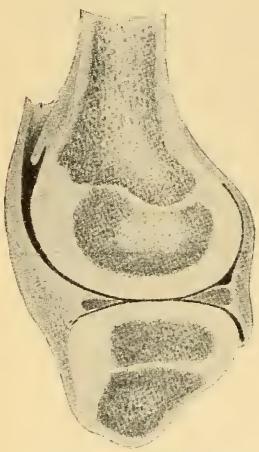
CHAPTER IX.

TUBERCULOUS DISEASE OF THE KNEE JOINT.

Synonyms.—White Swelling, Tumor Albus.

Tuberculous disease of the knee joint is next in frequency and importance to that of the hip. It is however far less dangerous to life, and the prognosis, as regards function, is much better than in the former affection. This is explained by the simplicity of the joint and by its situation at a distance from the trunk, at the junction of two levers of nearly equal length and size. Thus the problem of treatment, and more especially of protection by mechanical means, is comparatively simple; consequently it is more often applied, and in proportion to its efficiency the injury of functional use is lessened and the tendency to deformity is checked.

FIG. 218.



Section of the knee joint at the age of seven years, showing the epiphyses of the femur and tibia and their relation to the capsule. (KRAUSE.)

Pathology.—The disease may begin in the epiphysis of the femur or in that of the tibia, occasionally in the patella or in the head of the fibula, or primarily in the synovial membrane.

In 547 cases,[1] about two-thirds of which were in adults, treated at Koenig's clinic in Göttingen by operative procedures which permitted inspection of the joint, 281 (51.4 per cent.) were apparently examples of primary osteal disease; 266 (48.6 per cent.) were primarily synovial. The focus was in the femur in 93 instances (33.1 per cent.), in the tibia in 107 (38.1 per cent.), in the patella in 33 (11.7 per cent.), and in more than one bone in 48 (17.1 per cent.).

The examination of a joint permitted by arthrectomy or excision, can not be sufficiently thorough to exclude disease of the bone and to establish the diagnosis of primary disease of the synovial membrane, but in 92 instances the opportunity was offered by amputation at the thigh, eighty of the patients being adults. This examination, presumably thorough, showed the primary disease to be of the bone in 50 cases, while in 35 the synovial membrane was apparently the seat of the primary affection.

In 17 of the 50 cases in which the disease was osteal, the focus was in the femur; in 7 it was in the internal condyle, in 6 in the external

[1] Die Specielle Tuberculose der Knocken und Geleke, Berlin, 1896.

condyle and it was in other situations in 4 cases. In 17 the primary disease was of the tibia; in 5 of the internal tuberosity, in 5 of the external tuberosity, in other situations 7. In 5 instances the primary disease was of the patella, and more than one bone was involved in 11 cases. Nichols[1] states that he has examined 120 tuberculous joints of adults and children, after excision, amputation and at autopsy, and in every instance primary foci in the bone were discovered. He believes primary disease of the synovial membrane to be very uncommon and asserts that examinations are of no particular value as establishing the absence of primary osteal disease unless the bones are sawed into thin sections. This is the view generally held in this country, that in the great majority of cases the disease of the bone precedes the disease in the interior of the joint. From the clinical standpoint, however, one recognizes two distinct types of tuberculous disease: one, beginning as a chronic synovitis in which the early symptoms are subacute, a type more often seen in adults (Fig. 220); and the more common class, in which the symptoms of pain, muscular spasm and deformity, seem to indicate clearly a primary disease of the bone.

The proximity of the active disease in the neighborhood of the joint sets up a sympathetic hyperæmia within it, and an accompanying synovitis. If the disease is progressive the synovial membrane becomes thickened and adhesions form between its folds that gradually lessen the capacity of the joint and diminish its mobility. When perforation takes places the granulation tissue spreads over the surface of the cartilages destroying them in its progress and eroding the underlying bone; or if the joint is filled with tuberculous pus they may be macerated and separated in necrotic shreds. The direct destructive effects of the disease are increased by pressure and friction when the part is not protected by mechanical means. The hypertrophied synovial membrane and the thickened and diseased capsule cause the peculiar elastic resistance on palpation, called pseudo-fluctuation. In more advanced cases there is also a reactive inflammation in the over-lying tissues, accompanied by a formation of fibrous tissue that involves the tendons and muscles. These changes within and without the joint cause the firm resistant tumor characteristic of "white swelling."

Etiology.—The etiology of tuberculous disease has been discussed in Chapters V. and VII.

Statistics.—Tuberculosis of the knee-joint is essentially a disease of early life although it is less strictly confined to childhood than is disease of the spine or hip. Sex exercises but little influence and the two sides are affected in nearly equal numbers. These points are illustrated by the following table of 1,000 consecutive cases treated at the Hospital for Ruptured and Crippled.[2]

[1] Trans. Am. Orth. Ass'n, Vol. XI.

[2] These statistics, together with those of tuberculous disease of the joints, other than of the hip, were collected for me by Drs. F. C. Bradner, S. E. Sprague, E. L. Barnett, and S. W. Stone, House officers at the Hospital, 1900–1901.

AGE AT INCIPIENCY OF KNEE JOINT DISEASE.

1 year or less	25	22 years old	13
2 years old	45	23 " "	12
3 " "	91	24 " "	8
4 " "	164	25 " "	3
5 " "	84	26 " "	2
6 " "	75	27 " "	4
7 " "	66	28 " "	5
8 " "	74	29 " "	7
9 " "	65	30 " "	1
10 " "	60	31 " "	1
11 " "	46	32 " "	2
12 " "	20	33 " "	1
13 " "	19	34 " "	1
14 " "	17	35 " "	4
15 " "	12	36 " "	0
16 " "	10	37 " "	2
17 " "	20	38 " "	1
18 " "	8	39 " "	1
19 " "	8	40 " "	1
20 " "	8	41 " "	1
21 " "	12	50 " "	1
		Total	1,000

Males 512—Females 488. Right 485—Left 515.

Symptoms.—The general characteristics of tuberculosis have been described in the chapters on Pott's disease and hip disease. In the description of these affections, however, but little stress was laid on local sensitiveness and local swelling because in these situations the diseased parts lie at a distance from the surface and are concealed by the muscles and other tissues. At the knee, on the other hand, the joint is superficial, and even slight effusion into the capsule changes, to a perceptible degree, its contour, while sensitiveness to pressure, elevation of the local temperature and thickening of the tissues are usually present.

Even when the patients are seen at a comparatively early stage of the disease, as regards the physical condition of the joint, the history of the affection will almost always show that it is chronic and progressive in character. The importance of establishing this fact has been mentioned in the consideration of hip disease, and it may be stated again that a chronic painful disease of a joint, accompanied by a tendency to deformity, is, in childhood, almost always tuberculous in character.

The symptoms of tuberculous disease may be classified as **limp, pain, local heat, sensitiveness and swelling, muscular spasm and limitation of motion, distortion and atrophy.**

On physical examination one will note the character of the limp, and the slight flexion of the limb which usually accompanies it. The joint is, as a rule, somewhat enlarged, and the normal depressions about the patella and the projection of the component bones, are less accentuated than on the opposite side. There is usually slight local elevation of

temperature and sensitiveness to pressure, varying in degree with the character of the disease. In certain cases a degree of effusion is present, sufficient to cause the symptoms of synovitis, but in most instances the swelling is due, in great part, to the hyperæmia and thickening of the synovial membrane and the capsule, which gives the sensation of elastic resistance rather than actual fluctuation.

The most important sign is limitation of the range of motion caused by muscular spasm. The normal range is from complete extension, 180 degrees, to a degree of flexion, limited only by the apposition of the calf and the posterior surface of the thigh. Even in the early stage of disease, a slight limitation of complete extension is present, due to reflex muscular spasm, and usually a corresponding limitation of the complete flexion; on sudden movements, the characteristic reflex contraction of the muscles is apparent. In most cases this limitation of motion and consequent flexion deformity, is well marked on the first examination. Atrophy of the muscles of the thigh and calf, dependent upon the duration of the disease and upon the interference with function, is present, and this atrophy is more noticeable because of the enlargement of the knee.

In certain cases, more often seen in infancy and early childhood, the symptoms are more acute and the progress of the disease is more rapid, so that it may simulate an infectious epiphysitis. (Fig. 219.)

Fig. 219.

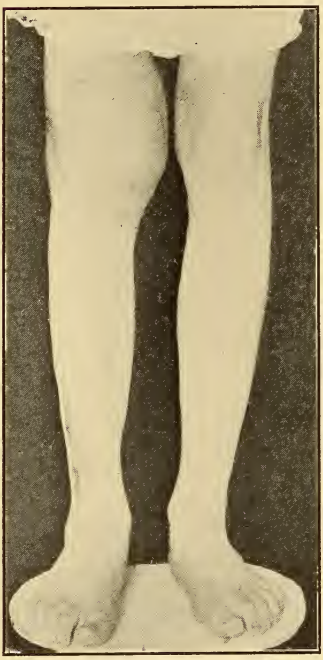
Acute tuberculous arthritis of the knee.

In another type, which is more common in adults, the early symptoms are very similar to those of simple chronic synovitis. The joint is swollen by a distension of the capsule, pain is not marked and muscular spasm and limitation of motion are evident only after a careful examination. In this class months or years may pass before the symptoms become as disabling as when they are characteristic of the osteal type of the disease.

Primary and Secondary Distortions of Knee Joint Disease. —At the hip joint, in which the range of motion is extensive, the de-

formities resulting from disease are somewhat complex, causing, for example, apparent shortening or lengthening, according as the limb is adducted or abducted. But the movements that the knee joint permits are much simpler, and the primary distortion is simply flexion. Complete extension of the limb, the limit of normal motion in that direction, brings the joint surfaces into close apposition ; the ligaments are then tense and no lateral motion is permitted. This is the attitude in which the greatest efficiency of the limb for weight-bearing, is assured. When the ability of the knee for carrying out its normal weight-bearing function is lessened by disease which makes the parts sensitive to pressure and to strain, the range of extreme motion in both extension and flexion is lessened and the limb is persistently held in flexion to a greater or less degree, dependent upon the sensitiveness of the joint. The agents that adapt the limb to the habitual attitudes are the muscles under the control of the nervous system. In this sense the primary distortions are due to muscular action, but it is certainly not true that these muscles antagonize one another, and that the stronger overcoming the weaker cause the deformity, since the extensors at this joint are stronger than the flexors, and since flexion is the primary deformity at every joint which is diseased without regard to the relative strength of the opposing muscular groups.

FIG. 220.



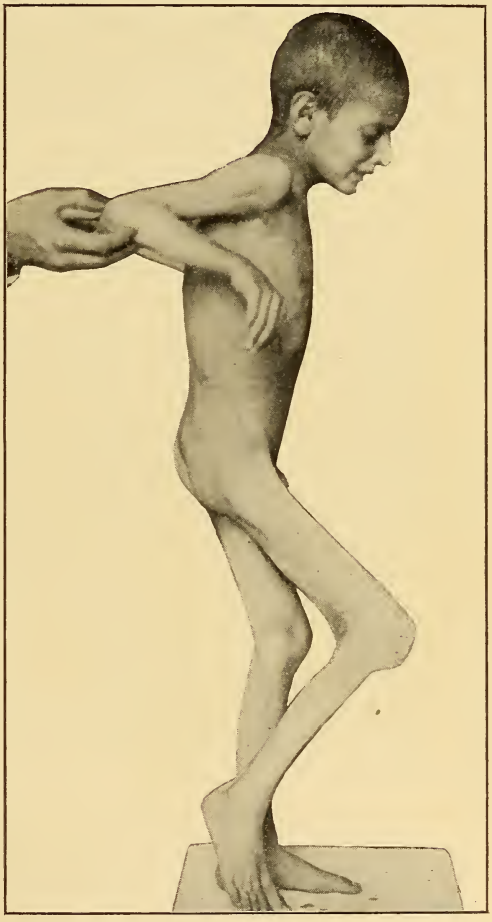
Tuberculous disease of the knee in an adult. The synovial type.

In disease at the knee joint, as at other joints, the extremes of motion in every direction that the joint permits are limited by muscular spasm, but limitation of extension, which is so essential to normal use, is at once evident, while limitation of flexion, the extremes of which are unessential, is only apparent on examination. Flexion is then the primary distortion at the knee, and other deformities may be classed as secondary.

SECONDARY DEFORMITIES.—Of these the most common is outward rotation of the tibia upon the femur. When the limb is fully extended there is no lateral motion at the knee, but when it is flexed lateral motion is possible, and in the attitude of flexion the traction of the biceps upon the head of the fibula tends to rotate it upon the femur. This deformity is also favored by the use of the limb in the attitude of outward rotation, which is always assumed when the weakness or stiffness of the knee joint is present, and by the secondary knock knee that often accompanies the disease.

Subluxation or backward displacement of the tibia upon the femur, is another secondary deformity. When the leg is flexed upon the thigh the articulating surface of the tibia glides backward upon the condyles of the femur. Here it becomes fixed by muscular contraction, and later, by the secondary changes within the joint. If muscular spasm be extreme, this alone might cause the subluxation, but there are other factors; one is the destructive action of the disease which is usually most marked at the point at which the bones are in contact, and the other is the leverage exerted upon the leg. This is exemplified by the increase of the displacement that is often observed when an attempt is made to straighten the limb by force, against the resistance offered by the contracted tissues on the flexor aspect. The same leverage, in slighter degree, is exerted when the weight of the distorted limb is supported on the heel in the recumbent posture, or when the limb is extended in the act of walking, or if the upper extremity of the tibia is not supported during the period of treatment by apparatus.

FIG. 221.



Untreated disease of the knee joint illustrating the hypertrophy of the condyles of the femur, the subluxation and outward rotation of the tibia, the atrophy and the characteristic deformity.

Knock knee (genu valgum) is another secondary deformity. This is explained in certain instances by the hypertrophy of the internal condyle caused by disease, but it is induced more directly by the use of the flexed and somewhat disabled limb in the passive attitude of outward rotation. Genu varum is uncommon and it is usually the result of the destruction of a part of the external condyle of the femur or of the tibia.

The character and the relative frequency of the deformities are in-

dicated by the statistics from Koenig's[1] clinic, of 150 cases of knee joint disease treated by arthrectomy, 128 of these being in children. In 94 cases flexion was present; in 50 from a slight degree to 135 degrees; in 16, from 135 degrees to 90; in 28, to a right angle or less. Together with the flexion were combined other deformities as follows: Genu valgum in 60 cases; moderate in 42; extreme in 18. Genu varum in 1 case. Subluxation of the tibia in 20 cases. Outward rotation of the tibia in 10 cases.

As has been stated, the primary deformity of knee disease is simple flexion. If the disease is of an acute type this flexion increases rapidly. If it is subacute in character, and especially if the clinical signs indicate that the disease is primarily of the synovial membrane, the progress of the deformity is slow. In ordinary cases the other deformities appear at a later time when the disease has reached the destructive stage; and they are most marked in patients who have persistently used the deformed limb without protection.

Actual Shortening and Actual Lengthening.—Retardation of growth is of course not an early symptom of disease, in fact actual lengthening of the limb, due to the irritative effect of the disease upon the epiphyseal cartilage of the femur or of the tibia, is common. This lengthening, sometimes to the extent of an inch or even more, may persist throughout the entire course of treatment, but after the cure of the disease a corresponding retardation of growth that will more than equalize the length of the limbs, may be expected. And when the disease is of the destructive type, the ultimate shortening may be considerable, two or more inches is not unusual.

Leusden,[2] in 33 cases under treatment in the clinic at Göttingen, 1896–1898, found slight shortening in 2, equality of length in 18, lengthening of the femur on the diseased side in 13.

116 cases of tuberculous disease of the knee were measured by Berry and Gibney[3] with reference to this point. In 72 of these there was actual lengthening of the femur, from which, it may be inferred that in at least 62 per cent. of the cases examined the primary disease was of the femur.

In 17	¼	inch.
" 34	½	"
" 15	¾	"
" 6	1	"

72—62 per cent.

Diagnosis.—Tuberculous disease is a local destructive process that is, as a rule, confined to a single joint. This is an important point in the differential diagnosis from general or constitutional affections like rheumatism, rheumatoid arthritis and the like, in which several joints are involved. The following conditions may be considered.

Injury of the Knee.—Strains of the knee in childhood are often followed by limp and persistent flexion and pain on motion. In such

[1] Trans. Am. Orth. Ass'n, Vol. XI. [2] Deutsche Zeits. f. Chir., Bd. 51, H. 3 and 4.
[3] Am. Jour. Med. Sci., Oct., 1893.

cases the onset is sudden and the symptoms usually disappear quickly under treatment. Synovitis of traumatic origin is usually indicative of a more severe injury. When synovitis persists, the diagnosis may be doubtful because tuberculous infection may have followed the original injury. This emphasizes the importance of the careful treatment and continued observation of injuries of this class, especially in weakly children.

Synovitis.—Chronic synovitis of doubtful origin, which shows no tendency toward recovery, is usually tuberculous in character.

Hæmophilia.—Effusion of blood into the knee joint may cause inflammatory symptoms during the stage of absorption and organization of the clot, that resemble those of disease. The sudden onset and the personal history of the patient, who may be known as a bleeder, will explain the symptoms. (See page 216.)

Infectious Arthritis—Acute Epiphysitis.—This is of sudden onset, attended by the constitutional and local symptoms of suppuration.

Rheumatism.—This, in early childhood, may be confined to a single joint, but it is of sudden onset and is usually accompanied by constitutional disturbance, and after a time other joints become involved.

Rheumatoid Arthritis—Osteo-arthritis.—This affection, of the monarticular form, is a disease of adult life. It is usually characteristically "rheumatic" in symptoms.

Charcot's Disease.—Charcot's disease of the knee joint is characterized by sudden effusion, by rapid destruction of the joint and consequently by weakness and deformity; but pain is usually very slight and muscular spasm is absent. The diagnosis of the disease of the spinal cord will explain the condition of the joint. (See page 217.)

Sarcoma.—Sarcoma, beginning in or near the epiphysis of the femur or of the tibia, may simulate tuberculous disease very closely. If the tumor is of the periosteal type, it usually forms a more localized and irregular swelling than could be accounted for by tuberculous disease. Central sarcoma may simulate tuberculosis very closely, but the progress of the tumor is more rapid. The clinical distinction between the two is that tuberculous disease is very amenable to treatment, as far as its symptoms are concerned, while the progress of sarcoma is but little influenced by treatment. It may be stated, however, that the X-ray is the only means of early diagnosis, as the destruction of the substance of the bone about the tumor is much greater than that caused by tuberculous disease.

Hysterical Joint.—Some of the symptoms of disease may be simulated by hysterical subjects, but there is always an absence of the positive physical signs that invariably accompany a destructive disease.

Treatment.—The treatment of tuberculous disease of the knee in childhood is conservative, operative intervention being simply incidental to protective treatment, while in adult life the radical removal of the disease may be indicated as the primary measure.

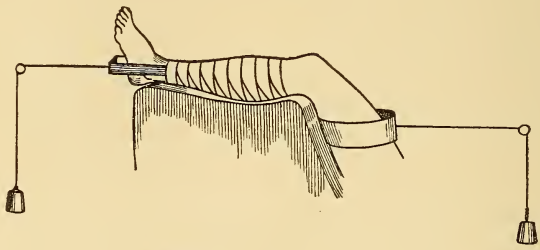
The reasons for this distinction are obvious. In childhood the duration of treatment is of no particular importance as compared with

the final functional result, but in adult life the shortening of the period of disability and the definite assurance of cure may be of far greater moment than the preservation of motion.

Under favorable conditions in childhood the prognosis of recovery, with fair functional use of the joint, is good; while a radical operation, although it may cure the patient in a shorter time, takes away the possibility of a cure with motion. In adult life a rigid limb is a strong, useful, if somewhat awkward, support, but in childhood the removal of portions of the epiphyses and of the epiphyseal cartilages entails a progressive inequality in the limbs, due to loss of growth, and unless the limb is protected by mechanical means, deformity is the rule, even though the disease has been thoroughly removed. (Fig. 228.) Thus the treatment of routine is, in childhood, at least, protection; protection from the traumatism of motion, from the shock of impact with the ground and from the pressure of muscular spasm and contraction.

Mechanical treatment, which is so difficult at the hip, is comparatively easy at the knee and as has been stated the results are correspondingly better. At the hip joint one of the most common causes of

FIG. 222.



Extension and counter-extension in disease of the knee joint. (MARSH.)

shortening and deformity is upward displacement of the femur upon the pelvis, but at the knee, if the limb is supported in the attitude of extension, the apposition of the broad surfaces of the femur and the tibia, prevents displacement, while muscular spasm, a symptom whose intensity is in proportion to the degree of harmful motion that is permitted, is easily controlled by efficient splinting.

Reduction of Deformity.—The first step in treatment is the reduction of deformity that may be present, in order that the limb, at the beginning as well as throughout the entire course of treatment, may be in absolutely normal position; and as the chief function of the leg is to support weight, the proper attitude is complete extension. Whatever motion the patient retains will then be at the point of greatest usefulness. In the cases in which an opportunity for reasonably early treatment is offered, the only deformity is flexion, a deformity caused almost entirely by muscular spasm; although if it has persisted for some time secondary retraction of the muscles may be present. In this class of cases the spasm, and consequently the deformity, may be readily overcome by splinting the part while the patient is confined to the bed.

The Plaster Bandage.—The most efficient splint is a close-fitting plaster bandage, applied from the groin to the ankle, or better, to include the foot, in order to prevent œdema of the unsupported part, which is common after the first dressing and until the circulation of the limb has become adapted to the new conditions. In the application of the bandage the bony prominences of the knee and ankle are protected by pads of cotton. A canton flannel bandage is then applied smoothly, and directly upon this, the light plaster bandage. At the second application, at the end of a week, the subsidence of the spasm will permit the straightening of the limb. In cases of longer standing, several successive applications of the bandage may be required, together with manual extension during the application; or an anæsthetic may be administered which, relieving the muscular spasm, will allow of immediate replacement. Under anæsthesia the more resistant deformities may be reduced by traction and by slight leverage, the head of the tibia being supported and drawn forward by the hands, as the deformity is gently reduced.

Fig. 223.

Tuberculous disease of the knee in an adult, with the form of Billroth splint used at the Hospital for Ruptured and Crippled.

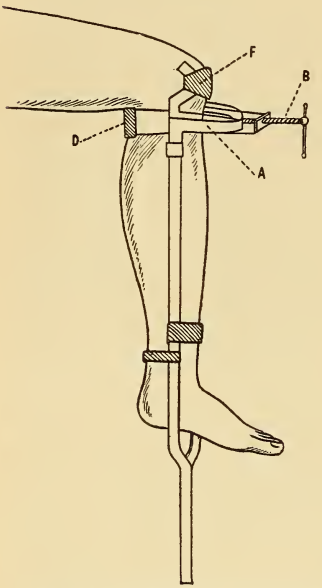
Traction.—Deformity may be reduced also by traction with the weight and pulley, the leg being supported so that no direct leverage is exerted at the seat of disease. (Fig. 222.)

The Billroth Spint.—In more resistant cases the Billroth splint as modified by Stillman, may be employed. A thick pad of felt is placed over the upper surface of the condyles of the femur and a thinner pad in the popliteal region over the upper border of the tibia. Other points that may be subjected to pressure are similarly protected, especially the dorsum of the foot and the perineum. A plaster bandage is then applied from the groin to the toes, made especially thick and strong in the popliteal region. On either side of the knee, two curved slotted steel bars attached to expanded tin splints and joined to one another by an adjustable bolt, are incorporated in it. (Fig. 223.) When the bandage hardens, it is completely divided into two parts, by a circular cut about the knee and the bolts in the slots are so adjusted

as to form a hinged splint, the center of motion being somewhat above and in front of the knee joint. When the limb is slightly extended, the position of the hinges has a tendency to lift the tibia and to separate it from the femur. This straightening opens the cut in the popliteal region, which is held open by a wedge of cork. In this manner, by the insertion of larger wedges, the limb is gradually straightened from day to day until the deformity is overcome, or until a new bandage is required. If the pressure on the front of the femur, when the leverage is exerted, becomes painful, a part of the padding is removed.

Forcible Correction.—In very resistant cases, division of the contracted parts by subcutaneous or open incision, may be required; or the Goldthwait genuclast may be used. (Fig. 224.) The more violent methods should not be employed during the active stages of the disease; and whenever considerable force is required, in young subjects, the possibility of separating the epiphysis of the femur, forcing it backward and thus pressing upon the popliteal vessels, should be borne in mind.

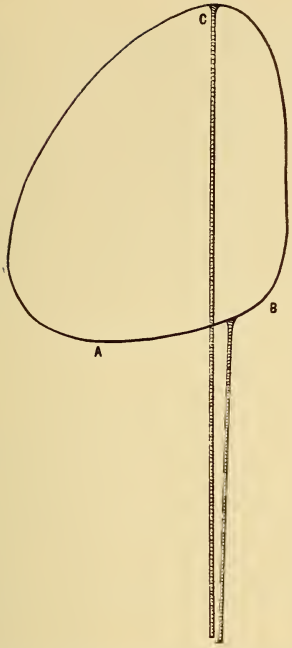
Fig. 224.



Goldthwait's genuclast for the correction of flexion deformity and subluxation at the knee.

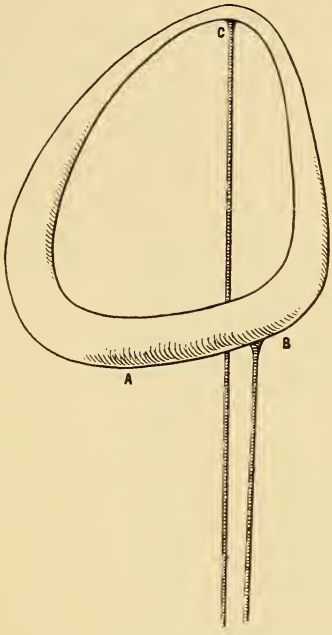
Mechanical Treatment. — The most efficient mechanical appliance for the treatment of tuberculous disease at the knee, is the **Thomas Knee Brace.** This consists of two lateral uprights which support the limb on either side, terminating below the foot in a crossbar shod with leather or rubber, which serves as a stilt, and above in a ring that fits the upper extremity of the thigh, and supports the weight of the body. The brace is made of iron wire from three-sixteenths to three-eighths of an inch in thickness. The ring is of an irregular ovoid shape, flattened in front, expanded behind, and wider on the inner than on the outer side. (Fig. 225.) This ring is welded to the uprights at a lateral and antero-posterior inclination. The lateral inclination forms an angle with the inner bar of 135 degrees (Fig. 227), the antero-posterior inclination forms an anterior angle of 145 degrees (Fig. 225) with the same upright, which is set upon the ring at a point slightly in advance of its fellow. The objects of the shape of the ring and of its inclination are these: its anterior part is flat because the surface of the groin is flat; its posterior segment is expanded to accommodate the thickness of the buttock, the antero-posterior inclination allows the ring to rest comfortably beneath the tuberosity of the ischium. The lateral inclination is made necessary by the greater length of the outer bar which, in order to assure

FIG. 225.



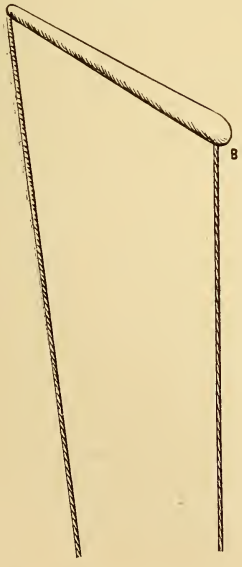
The Thomas knee-splint, showing the inner bar, B, placed farther to the front than the outer bar C; A is the lowest part of the ring; upon this rests the tuberosity of the ischium.

FIG. 226.



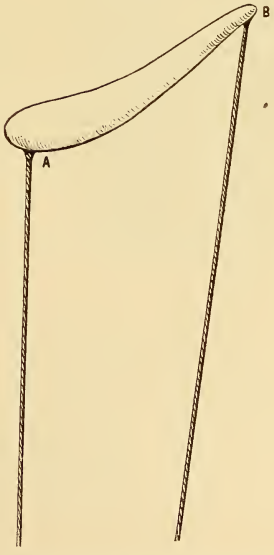
The ring of the Thomas knee-splint after padding. (RIDLON.)

FIG. 227.



Showing the front of the ring of the Thomas knee splint.

FIG. 228.



Showing the back of the ring of the Thomas knee splint. (RIDLON.)

better support and less pressure, rises above the level of the trochanter major.

The ring is made somewhat larger than the thigh to allow for padding with felting, which should be thicker on the inner and posterior surface, where the weight is borne, than on the anterior and outer part. The padding is then smoothly covered with basil leather. As used at the Hospital for Ruptured and Crippled, the brace is made from two to three inches longer than the leg, to serve as a stilt like the hip splint. To the foot piece two straps are attached on either side to provide for traction on the limb and for the support of the brace. A band of leather is drawn between the bars at the upper third and another at the lower third of the brace, to serve as supports for the thigh and calf. Adhesive plasters, reaching from the knee to the ankle, provided with buckles above the malleoli, having been applied, the ring is pushed firmly against the perineum and is held in position by buckling the straps to the adhesive plasters with as much traction as the comfort of the patient will permit. The thigh and leg supports should fit the parts perfectly; the knee is then fixed in its place by a bandage drawn tightly about it and the lateral bars, and a strap is applied about the ankle. (Fig. 229.) In cases in which the joint is sensitive and in which there is a tendency to deformity, the entire limb is in addition enclosed in a light plaster bandage, so-called "skin fitting," applied directly upon a flannel bandage.

Fig. 229.

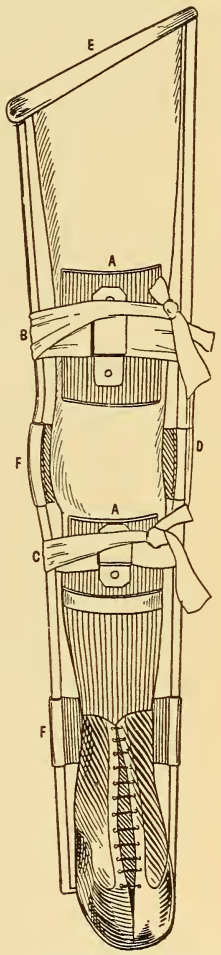
The Thomas knee brace.

If the brace is attached by means of the adhesive plaster straps, a certain amount of traction is assured, together with additional accuracy of adjustment; and by the traction and by the direct pressure on the knee the slighter degrees of deformity may be reduced without discomfort. In acute cases preliminary rest in bed is advisable, and crutches may be employed in the early stages of ambulatory treatment. But during the greater part of the disease the splint serves as a perineal crutch and by the use of slight corrective force when the plaster bandages are applied, or by traction at times toward one or the other upright, lateral distortion of the limb may be corrected during the course of treatment. This brace may be used in the treatment of very young children, if it is carefully fitted

and if the parts are kept clean and dry, and it is an effective brace for all ages and for all conditions of disease.

The Caliper Brace.—The traction may be discarded and the brace may be held in position by a shoulder band, or it may be used as a so-called caliper splint. In this form it was almost exclusively employed by Mr. Thomas in his later practice and at the present time by Ridlon,[1] the long brace being used simply for a bed splint. As a caliper brace the two bars are cut off and turned directly inward at a right angle, are inserted into a steel tube which is passed through the heel of the shoe. The bars are made slightly longer than the leg so that the patient's heel is lifted nearly an inch from the inside of the shoe when walking; thus the jar of impact with the ground is prevented. The brace is fixed in position by a leather band beneath the knee and another beneath the calf, and the limb is held extended by pressure pads applied to the thigh and leg, as illustrated. (Fig. 230.) Ridlon uses the brace to reduce deformity by direct pressure backward on the knee by means of bandages, opiates being given to relieve pain.

Fig. 230.



The caliper splint. E, the ring around the upper part of the thigh; A, pad for backward pressure; B, bandage; C, bandage; F, leather sling for support at the back of the limb; D, a strip of bandage fastening together the pressure pads to prevent slipping and consequent loss of pressure. (Ridlon and Jones.)

Other braces may be employed, for example the traction hip splint (Figs. 203, 204), but as the Thomas brace answers every requirement, it seems unnecessary to describe others in this connection.

Treatment During Convalescence.—During the active stage of the disease the brace must be worn day and night; during the stage of recovery it may be removed at night, to allow for motion at the knee, and later a form of walking brace (Fig. 205) that will allow a limited motion at the knee, may be of service; but this is not an essential in treatment. If a certain amount of knock knee remains after recovery, it may be overcome by the use of a Thomas knock knee brace which will also serve as a protective splint.

The indications of cure have been discussed under hip disease. In brief, when sufficient time has elapsed to permit of natural cure, when there has been no symptom of active disease for months, when muscular spasm has disappeared, one may tentatively remove the brace in the manner described. But any symptom of disease and particularly increasing limitation of the range of motion, or a tendency toward deformity, indicates the necessity for continued protection.

[1] Trans. Am. Orth. Ass'n, Vol. VI.

If anchylosis be present, supervision and occasional treatment will be required during the period of growth in order to prevent deformity.

Extra-Articular Disease.—In certain cases, especially in young children, the disease about the epiphyseal cartilage of the femur or of the tibia, may find its way to the exterior of the bone before it perforates the capsule. This is suggested by local sensitiveness and swelling over one of the condyles of the femur or about the head of the tibia. In such instances, the thorough removal of the disease is indicated, or if a Roentgen picture shows that the disease is accessible, even though it is not immediately below the surface, an exploratory operation may be advisable. In favorable cases prompt operative intervention may cut short the course of the disease.

Abscess.—Abscess is present as a complication in about one-third of the cases that have received efficient protection, and in a larger percentage of the cases in which treatment has been neglected.

It was present in 51 per cent. of Koenig's cases [1] and in 47 per cent. of three hundred final results reported by Gibney.[2] At the knee as at other joints, the infected abscess is the most dangerous complication of the disease, as is illustrated by Koenig's statistics.

Death rate in cases without abscess.....25 per cent.
" " " " with " .....46 per cent.

Although in many instances, abscess indicates an extensive and destructive disease of the bone, yet the exhausting suppuration that is an indirect cause of death, is suppuration from infected areas in the thigh and leg, which may have little direct relation to the extent of the original disease. It should be the aim in treatment to prevent this burrowing of fluid after the capsule has been perforated, and to prevent over-distention of the capsule even, in order to lessen the macerating effect of the tuberculous fluid upon the cartilages. When the fluid within the capsule is of an appreciable amount, and when it is increasing in quantity, it may be removed by aspiration; or, a better procedure is to incise the capsule. This will allow a thorough removal of its fluid and solid contents, after which the opening may be closed with sutures.

Tuberculous abscess which has perforated the capsule may be treated in the same manner, or it may be drained subsequently, according to the indications. Unless the abscess is infected, careful bandaging of the thigh and leg should prevent burrowing.

Synovial Tuberculosis.—In the forms of synovial tuberculosis that resemble chronic synovitis the fluid may be evacuated by an incision in the capsule which will allow for exploration and for removal of the fibrinous masses that are often present. Afterwards the interior of the joint may be treated with an application of a strong solution of chloride of zinc, or carbolic acid. This sets up an active inflammation which causes adhesions within the capsule, and exerts a favorable influence on the course of the disease. The injection of iodoform emul-

[1] Trans. Am. Orth. Ass'n, Vol. VI. [2] Am. Jour. Med. Sci., Oct., 1893.

sion has been extensively employed in the treatment of tuberculosis of the knee at the Hospital for Ruptured and Crippled, but no decided benefit has been observed. Theoretically its use should modify the infectious quality of the tuberculous fluid, and lessen the danger of infection with pyogenic germs, and on this ground, rather than because it actually shortens the course of the disease, it may be recommended. (See Bier's treatment, page 203.)

Arthrectomy.—When, as in exceptional cases, the disease is progressive and shows no tendency toward recovery, and particularly if an infected abscess communicating with the joint makes efficient drainage difficult, the operation of arthrectomy may be indicated.

An Esmarch bandage having been applied, the joint is thoroughly exposed by a curved anterior incision passing above or below or through the patella, and all the diseased tissue is removed; that in the soft parts is cut away, and foci in the bone are removed with the chisel and scoop. If infection be present the joint may be packed with gauze, the leg being fixed in the position of flexion; but in other instances the wound is closed, with or without drainage as may seem advisable. In a large proportion of cases primary healing may be obtained. By the procedure one may hope to cure the disease, but in all but exceptional cases the functional result will be anchylosis. The operation has the advantage over excision in that less bone is removed, and that the epiphyseal cartilages, in part at least, remain; thus the immediate as well as the ultimate shortening is less than after excision.

Results of Arthrectomy.—The direct death rate of the operation is small. In 150 cases, reported by Koenig, but 3 deaths were attributable to the operation itself. The final results in 114 of these cases, in which the operation was performed in childhood, were as follows:

Patients cured and living	90	
Cured of the local disease but not living at the time of the investigation	10	
Practically cured, insignificant fistulæ remaining	2	
	102	—89.5 per cent.
Living, not cured	5	
Deaths before the cure of the local disease	7	
	12	—10.5 per cent.

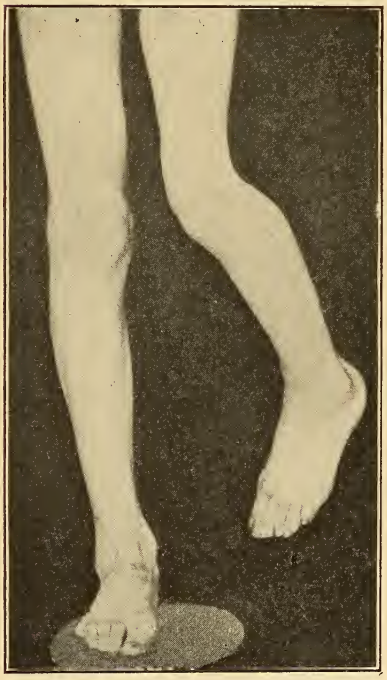
Thus in 89 per cent. of the cases the operation was successful as far as the cure of the local disease was concerned. In 75 per cent. of the successful cases, immediate cure was attained; in 25 per cent. fistulæ persisted for a longer or shorter time. In 10 cases some motion was retained, but in the others anchylosis followed the operation. In about 70 per cent. of the cases the limb was practically straight; in 30 per cent. it was distorted. This shows the necessity of continued supervision during the growing period of all cases in which anchylosis is present from whatever cause.

In 48 cases in which the operation had been performed before the tenth year, and in which the limbs were straight, the influence of the operation on the growth was investigated.

Years elapsed since operation.	Number of cases.	Average Shortening in Cm.
2	6	1
3	5	1.6
4	4	1
5	3	2
6–7	19	2
8–13	11	2.5

These measurements indicate that the shortening is not likely to be very great as a result of the operation, certainly very much less than after complete or even partial excision, performed at the same age.

FIG. 231.



Deformity and shortening resulting from excision of the knee in childhood.

Excision.—Excision of the joint in childhood has been practically abandoned because of the great shortening that follows complete removal of the epiphyses, and because so-called partial excision, that is the removal of thin sections of bone from the surfaces of the femur and tibia leaving the cartilages, is usually an unnecessary operation, in the sense that disease that might be cured by this procedure might have been cured by conservative methods.

Early excision in adult cases is often indicated because it will assure a cure of the disease in a short time, whereas mechanical treatment will require years of disability with no certain prospect of absolute cure at the end of the period. If, therefore, the disease has progressed sufficiently to indicate that the natural cure would result in anchylosis, or if the time of disability is of importance to the patient, early excision may be advised in the case of the adult, or adolescent, whose growth is nearly completed.

The operation is performed under the Esmarch bandage, and the joint is exposed by the anterior incision, as in the operation of arthrectomy. All the diseased tissues are cut away and sections of the bones, parallel to the articular surfaces, are removed, sufficient in depth to

include all the diseased area. If the sections are so made as to allow the bones to be brought into close apposition, sutures through the periosteum will hold them in position, without nails or wiring. The vessels having been ligated, the wound may be closed with or without drainage, as may be indicated, a plaster of Paris dressing is applied, and the limb is elevated. Mechanical support is of service in the after-treatment in lessening the discomfort and hastening the cure.

Results of Excision.—In Koenig's statistics of three hundred excisions, 6 deaths were due directly to the operation, and 23 others occurred during the course of after-treatment; a total of 29 (9.6 per cent.).

In 23 instances amputation was afterwards performed because of failure of the operation. The good results are classed by Koenig as 75 per cent., the bad as 25 per cent. In 193 cases, the position of the limb in after years was investigated. It was straight in 175, distorted in 18; all but one of this latter group being in children.

Amputation.—This operation is indicated as a life-saving measure. When the disease is so extensive as to require complete removal of the epiphyses, in early childhood, amputation is the preferable operation, as the limb, aside from requiring constant protection to prevent deformity, will be so short as to be of little practical use.

Operations for the Relief of Final Deformity.—If the joint is anchylosed in an attitude of marked flexion, the limb may be straightened by the removal of a sufficient wedge of bone from the joint. Slighter degrees of flexion may be remedied by linear osteotomy of the femur.

Genu valgum may be corrected by a similar operation.

Prognosis.—The most important statistical evidence on the course and the outcome of tuberculous disease of the knee joint in childhood, has been presented by Gibney. The statistics completed in 1892 were the result of an investigation of four hundred and ninety-nine cases treated during a period of twenty years, 1868–1887. In but three hundred of these could definite information be obtained.[1]

Eighty-seven per cent. of the cases were in children, and 51 per cent. of the patients were less than five years of age at the inception of the disease.

The cases were divided into three classes, according to the treatment that had been followed:

1. The expectant treatment. In this class no apparatus was employed or, if employed, it was inefficiently used.

2. The fixation treatment. In this class the joint was more or less efficiently splinted, but not protected from impact with the ground.

3. The protective treatment. In this class the joint was both splinted and protected from jar, and the mechanical treatment was efficient.

[1] Am. Jour. Med. Sci., October, 1893.

The results were classified as follows:

	Total.	Excisions.	Amputations.	Deaths.	Under treatment.	Cured.
Expectant	71	5	3	3	9	51
Fixation	190	9	1	35	31	114
Protection	39	0	0	2	11	26
	300	14	4	40	51	191

MORTALITY.—The total deaths in the 300 cases were 40 (13.3 per cent.); 26 of these were from causes directly or indirectly connected with the disease (8.6 per cent.), viz.:

Operative shock	1
Prolonged suppuration	16
Tuberculous meningitis	6
Phthisis	3
	26
Intercurrent diseases	14
	40

FUNCTION.—The functional results, as regards motion, in the cases in which conservative treatment was continued to the end, including the cases still under observation, 242 of 300, were as follows:

	Total.	Motion retained.	Anchylosed.
Expectant	60	44 or 7 per cent.	16
Fixation	145	113 " 77 "	32
Protection	37	34 " 95 "	3
	242	191 " 79 "	51

Of the 191 patients who retained a movable joint 74 had had abscess, 3 or more cicatrices being present in 39.

As to the range of motion in 74 it was from 45 degrees to normal and in 41 more than 90 degrees, thus 30 per cent. of the patients retained a fair range of motion.

DEFORMITY.—In 51 cases anchylosis was present, in 16 of these the limb was practically straight, in 35 it was flexed more than 30 degrees (69 per cent.).

These statistics again illustrate the great tendency toward deformity, when during the growing period there is anchylosis at the knee from whatever cause.

In the 191 cases in which motion was retained the limb was practically straight in 125 (65 per cent.). In 49 others the flexion was less than 25 degrees and in but 16 could the deformity be classed as bad (8 per cent.).

In 10 cases only did relapse occur after apparent cure.

In but 16 of the 449 cases was there involvement of other joints

while the patients were under observation (3.2 per cent.). In 8 of these the spine was involved, in 2, the hip, and in 6 other joints.

The influence of age upon the death rate, and the ultimate causes of death, are illustrated by Koenig's statistics, the death rate being much higher, at least in the cases in early childhood, than in this country.

According to Koenig's statistics, the death rate, direct and indirect, from disease of the knee joint, was as follows:

323	children (1 to 15 years of age),	deaths	65 (20 per cent.)
225	patients (16 to 30 years of age),	"	61 (24 per cent.)
68	" (31 to 40 years of age),	"	30 (44 per cent.)
74	" more than 40 years of age	"	45 (60 per cent.)

Causes of Death.

Deaths from causes not connected with the disease, 14 (2 per cent.).

Deaths following operations, 18 (2.5 per cent.).

Deaths caused by tuberculosis, 141 (22.5 per cent. of all cases and 80 per cent. of all the deaths).

Tuberculosis of the knee	1
Tuberculosis of the lungs	94
General tuberculosis	30
Tuberculous meningitis	7
Acute miliary tuberculosis	3
Tuberculosis of other parts	6
	141

It may be noted that 16 of the 40 deaths in Gibney's cases were due to prolonged suppuration, and that of 51 cases still under observation 26 had been treated for ten years or longer, and were still uncured. This indicates, that in a larger proportion of the cases conservative methods should have been supplemented by more radical treatment. Still, taken as a whole, the results, although the mechanical treatment was, in many instances, far from efficient, are much better than any others that have been presented.

General Conclusions.—On this evidence the following conclusions seem to be justified. The death rate in childhood from all causes should be less than 10 per cent. The duration of treatment is from 2 to 5 years. Recovery with a useful range of motion, when the diagnosis has been made at an early stage and when efficient mechanical treatment has been employed, may be predicted in 50 per cent. of the cases.

Deformity can always be prevented by treatment and by supervision. Under favorable conditions, radical operations are not often indicated, but when indicated, they should not be delayed too long. Amputation of the limb should prevent death from prolonged suppuration. In a certain proportion of cases the disease may be cut short by early exploratory operations, for the removal of foci of disease in the bone before the joint has become involved.

Although the benefits of protective treatment are as evident in disease of the adult as in childhood, yet early operation is often indicated in this class, because of the necessity for shortening the period of disability, and because excision assures a straight and useful limb.

CHAPTER X.

NON-TUBERCULOUS AFFECTIONS AND DEFORMITIES OF THE KNEE JOINT.

Strains and Injuries of the Knee in Childhood.

Injury of the knee in childhood may cause local discomfort and persistent flexion of the leg, even when but little synovial effusion is present. In this class of cases the application of a plaster bandage is of service in resting the part and preventing further injury. The importance of treating promptly slight injuries of the joints in childhood, especially in the class of patients predisposed to tuberculous infection, has been mentioned already in the consideration of hip disease.

Synovitis.

Acute traumatic synovitis is properly treated, immediately after the injury, by splints, by elevation of the limb, by the application of ice bags and the like; but after the acute symptoms have subsided the absorption of the effused fluid is aided by functional use of the limb, if the joint is properly protected. One of the most efficient methods of treatment is that by means of the adhesive plaster strapping, advocated by Cottrell and Gibney. The entire surface of the knee, except a narrow space in the popliteal region, is firmly strapped with overlapping layers of adhesive plaster, extending from the upper third of the leg to the middle third of the thigh; and over this a flannel bandage is applied; or if the leg is swollen, the entire limb should be firmly bandaged with elastic stockinette bandage, from the toes to the upper third of the thigh in addition. (Fig. 238.) The adhesive plaster serves as a support which allows a certain degree of motion, sufficient to stimulate the circulation, and thus to hasten the restoration of the normal condition. If greater compression is desired, the entire joint may be covered with the adhesive plaster as suggested by Hoffmann.[1] A pad of cotton is placed in the popliteal space, a close-fitting stocking leg is drawn over the knee and about this circular bands of plaster are drawn as tightly as the comfort of the patient will permit. The adhesive plaster strapping is renewed from time to time, as the swelling diminishes and its use is continued until the symptoms have entirely disappeared.

Chronic synovitis may be treated in a similar manner, although if

[1] N. Y. Med. Jour., January 27, 1900.

the effusion is persistent the fluid may be removed by aspiration. If the ligaments are lax, a supporting brace may be required for a time (Fig. 152), and massage and exercises are of service in the stage of recovery.

Infectious Arthritis.

Suppurative arthritis in this, as in other joints, should be treated by free incisions, and efficient drainage should be assured. Under proper treatment practically perfect recovery is not unusual. Mechanical protection is usually required after the immediate symptoms are relieved. (See page 208.)

RHEUMATOID ARTHRITIS.

Osteo-Arthritis.

In this disease several joints are usually involved, but occasionally the affection may be confined to the knee. The early symptoms are stiffness, discomfort and pain more noticeable in damp weather, and often creaking sensations in the joint are appreciable to the patient. At intervals the symptoms may be more acute and the joint becomes hot and swollen, as in rheumatism; as a rule, however, they are subacute in character. The progress of the affection is slow, the joint becomes somewhat enlarged and irregular in outline, the range of motion becomes more restricted, and flexion of the limb, after a time, persists. (See page 212.)

Treatment.—The general and constitutional treatment of rheumatoid arthritis does not require especial consideration here. Locally, massage and the hot-air bath, may add to the comfort of the patient and increase the mobility of the joint, in the early stage of the affection, at least. Static electricity has been employed with advantage in certain cases. The application of the cautery and stimulating liniments are useful in relieving pain, and the support of a flannel bandage adds much to the comfort of the patient.

Prepatellar Bursitis.

Synonym.—Housemaid's Knee.

A chronic enlargement of the bursa lying over the patella and its ligament, is common among those who have to kneel much of the time, hence the popular name. Occasionally cases of acute bursitis, in which there is considerable effusion into the sac, are seen, and these are sometimes mistaken for synovitis of the knee.

Treatment.—In acute cases, strapping the front of the knee with strips of adhesive plaster which will limit motion and provide compression, is an effective treatment. If the effusion is considerable, it may be relieved by aspiration. In chronic cases, cure can be attained only by the removal of the thickened sac.

Pretibial Bursitis.

Beneath the ligamentum patellæ, occupying the space between the tendon and the periosteum of the tibia, is the deep pretibial bursa. It is, according to the investigations of Lovett,[1] as wide or somewhat wider than the tendon; its upper border is on a level with the joint, its lower border reaches to the tubercle of the tibia, and being slightly longer on the outer than on the inner border, it is somewhat triangular in shape. It does not communicate with the knee joint.

Enlargement of this bursa is, as a rule, the result of injury, but, as bursitis elsewhere, it may be a complication of infectious disease, rheumatism and the like.

Symptoms.—The symptoms are stiffness at the knee and pain on sudden movement, especially when strain is exerted on the tendon by complete flexion or extension of the leg as in active use. The tubercle of the tibia seems enlarged and is sensitive to pressure, and a swelling on either side of the ligament is usually evident.

Treatment.—The affection, if at all acute, may be treated by relieving the strain and pressure on the tendon, by fixation of the limb for a time in a plaster bandage, or other form of splint. Later, the adhesive plaster strapping will provide sufficient fixation and pressure. The absorption of the fluid may be hastened by the application of the cautery. If the swelling is persistent, the fluid may be removed by aspiration or incision of the sac. Its complete removal is not often necessary.

Enlargement of the Superficial Pretibial Bursa.

A small bursa, lying upon the insertion of the ligamentum patellæ, may become enlarged, causing an apparent hypertrophy of the tubercle of the tibia. It may be treated by strapping with adhesive plaster, and the prominent tubercle should be protected by some form of bunion plaster.

Bursæ and Cysts in the Popliteal Region.

Simple inflammation of the bursa lying between the inner head of the gastrocnemius and the semimembranosus muscle, may cause a fluctuating swelling on the inner side of the popliteal region. Cysts in the popliteal region usually communicate with the knee joint and are complications of rheumatic or tuberculous disease. They are of interest principally from the diagnostic standpoint.

Internal Derangement of the Knee Joint. (Hey.)

The term internal derangement signifies sudden interference with the function of the joint which may be due to: (*a*) Loose bodies in the joint; (*b*) Displacement of a semilunar cartilage; (*c*) Other injury.[2]

Loose Bodies in the Knee Joint.—Loose bodies in the knee joint may be composed of portions of fibrin, fragments of synovial mem-

[1] Boston City Hospital Reports, Eighth Series, 1897.
[2] W. H. Bennett, Lancet, Jan. 6, 1900.

brane or bits of cartilage or bone and the like. In certain forms of synovial tuberculosis and osteo-arthritis, these loose bodies may be present in large numbers, but from the therapeutic standpoint the important cases are those in which the joint is otherwise normal. In this class the foreign body is sometimes detected by the patient as a smooth, movable object on one or the other side of the patella; but in many instances the first sign of its presence is interference with the function of the joint. After a sudden movement or when the knee has been flexed, as in the kneeling position, or without appreciable cause, severe pain in the knee is felt and the joint may be fixed in the position of flexion. By massage, manipulation, or spontaneously, the foreign body is dislodged from between the surfaces of the bones and movement becomes free and painless, but discomfort remains for a time and in most instances synovial effusion follows. These symptoms recur at intervals and the disappearance of the movable body from its accustomed place at such times demonstrates its relation to the disability.

Displacement of a Semilunar Cartilage.—Displacement of a semilunar cartilage is usually of traumatic origin, and it appears to be caused most often by an outward twist of the tibia upon the femur. The patient's limb is fixed in the attitude of flexion, and in certain instances an irregularity may be detected at the inner and upper border of the tibia.

To replace the cartilage, the leg should be flexed then suddenly extended and rotated inward. In some instances an anæsthetic may be required. The displacement is followed by discomfort and synovial effusion, and the accident having once occurred, is likely to recur; the patient recognizing the character of the movements that are likely to cause the displacement, also the proper manipulation for its replacement.

Injury.—In other instances, somewhat similar symptoms may follow injury at the knee, pinching of the synovial membrane, bruising of the cartilage or a strain of one of the ligaments within the joint, being assigned as causes. In cases of this character in which the symptoms recur from time to time, the joint becomes weak and insecure, partly because of the repeated synovial effusions and partly because of the muscular relaxation.

Treatment.—Immediately after the displacement or injury, the joint should be splinted for a time, afterwards it may be protected by the adhesive plaster strapping, and when the effusion has been absorbed massage and exercises for strengthening the muscles should be employed.

In the more chronic cases in which the ligaments are lax, a brace which will permit antero-posterior motion, but prevent lateral mobility, may be required. The Campbell brace (Fig. 152) used by Shaffer, is a light and effective support that interferes little, if at all, with the use of the limb. If the diagnosis of displaced cartilage can be verified, and if it is the cause of persistent disability, it should be removed. And the same may be said of isolated foreign bodies, which are known to be the cause of the symptoms.

Congenital Genu Recurvatum.

Synonym.—Anterior Displacement of the Tibia.

The most common of the congenital deformities at the knee is the so-called genu recurvatum, in which the knee is bent somewhat backward, or in other words, the leg is hyper-extended on the thigh. The condition is often spoken of as an anterior dislocation, but there is no actual displacement, except in the extreme cases in which the tibia may be turned directly forward on the femur, even to a right angle or less. In the ordinary cases the range of extension is merely exaggerated, while flexion is limited or checked, principally by adaptive shortening of the quadriceps extensor muscle. (Fig. 232.)

The appearance in well-marked genu recurvatum is very peculiar, it is as if the patient's leg were reversed, for the popliteal depression has

FIG. 232.

Congenital genu recurvatum. (HOFFA.)

become a prominence and the range of over-extension seems to represent normal flexion. In such cases the leg may be brought to the straight line, but greater flexion is resisted by the retracted tissues, and when the pressure of the hand is removed the leg is drawn back to the deformed position by the contraction of the quadriceps extensor muscle.

OTHER DEFORMITIES AND MALFORMATIONS.—Genu recurvatum is not infrequently accompanied by varus or valgus deformity at the knee, more often by the latter, and by laxity of the ligaments. In many instances the patella is absent or is rudimentary and not infrequently the deformity is accompanied by malformations or defective development of other parts.

Seventy-eight cases were collected by Potel.[1] In thirty-seven instances the deformity was limited to one side, in the others both legs

[1] Etude sur les Malformations Congénitale du Genou. Lille, 1897, Imp. L. Danel.

were affected. In fifty cases the condition of the patella was noted, in twenty-six of these it was absent or rudimentary. Twenty of the cases were accompanied by talipes.

Etiology.—The deformity in cases of simple recurvatum may be explained by an abnormal and fixed position in utero, and in cases seen soon after birth the mechanism is clearly shown by the habitual attitude. The thighs are sharply flexed on the body, the dorsal surfaces of the hyper-extended knees are in relation to the abdomen, while the feet may be brought into contact with the face or trunk, according to the degree of deformity. The retarded development of the quadriceps extensor muscle explains the rudimentary patella which is often an accompaniment of the deformity.

Treatment.—The treatment of the hyper-extended knee is very simple. It consists in massage of the atrophied and contracted muscle, combined with more or less forcible manipulation in the direction of flexion. If, as is often the case, the leg seems to be drawn forward by spasmodic muscular action, the methodical massage should be combined with the use of a simple posterior splint.

In the more extreme cases manual force may be applied under anæsthesia, and the deformity may be overcome at one or several sittings, according to the resistance of the contracted parts. The leg is then fixed in a flexed position until the tendency to recurrence has been overcome. When the child begins to walk, a light lateral brace may be necessary to insure perfect functional use of the joint, as in many instances laxity of ligaments and muscular weakness may persist for a long time.

Rudimentary or Absent Patella.

As has been stated, a rudimentary patella is a frequent complication of genu recurvatum, or of any congenital defect or deformity of the knee or limb that involves imperfect development of the quadriceps extensor muscle. In many cases of this type it is impossible to distinguish the patella during the early months of infancy, but later, a minute patella appears that slowly increases to an approximately normal size.

Absence of patella under the same conditions is less frequent, although Potel collected one hundred cases from literature.

Treatment.—The treatment of rudimentary patella is included in the massage and stimulation of the atrophied or rudimentary muscle with which it is usually associated, and the support that the weak or deformed knee may require.

Congenital Displacement of the Patella.

The patella may be displaced upward as a result of extreme genu recurvatum, and in rare instances it may be displaced inward or downward, but far more often the displacement is outward. Fifty cases of this form are recorded, in most of which it was a complication of congenital genu valgum.

Slipping Patella.

This term is applied to an abnormal laxity of the supporting tissues that allows intermittent displacement of the patella upon, or to the outer side of, the external condyle.

Etiology.—The disability is more common among females than males and is more often unilateral than bilateral. The abnormal mobility may be an inherited peculiarity; it may be due to weakness of the quadriceps extensor muscle, or to imperfect development of the patella or of the external condyle; or the original displacement may have been due to injury. In many instances, however, the predisposing cause is genu valgum, as a consequence of which the patella is carried toward the external condyle.

Symptoms.—If the slipping of the patella is a frequent occurrence it causes comparatively little pain, but when the parts are less relaxed the displacement is likely to be followed by a certain amount of effusion into the joint and by the symptoms of a sprain. It is usually the result of a misstep or sudden movement when the thigh muscle is relaxed or of extreme flexion of the leg. As a rule there is a sense of insecurity and weakness at the knee in those who are subject to the accident.

Treatment.—The treatment varies according to the condition of the parts about the joint. If the displacement is the direct result of violence the leg should be fixed for a time in a plaster bandage, which may be replaced by the adhesive plaster strapping or a knee cap. Later massage and muscle training should be employed. In cases in which the slipping has become habitual and particularly when the ligaments of the joint are much relaxed, a light leg brace should be employed to prevent lateral motion and to limit the range of flexion at the joint, if this predisposes to the displacement.

Operative Treatment.—If the position of the patella that predisposes to the further displacement is a consequence of genu valgum the rectification of the deformity will, as a rule, remedy the secondary disability. If the displacement appears to be caused by laxity of the capsular ligament, as well as by the abnormal position of the patella, an operation for the purpose of limiting the mobility and restoring the proper relation of parts may be conducted in the following manner: A long curved incision is made about the inner side of the knee, the lower extremity of which crosses the ligamentum patellæ. The skin flap having been reflected the capsule may be divided on the outer side without disturbing the synovial membrane. The patella is then forced forward and the redundant tissue on the inner side is folded and sutured, or a section of the capsule may be removed, sufficient in size to hold the patella in its proper position. In extreme cases the tubercle of the tibia, with the attached tendon, may be removed and reimplanted on the inner aspect of the tibia, as performed by Wolff and Walsham.

The limb should be held in the extended position for a time, and it should afterwards be supported by a brace or knee cap for several

months. Subsequently massage, and exercise of the weakened muscle will be of advantage.

The operation for the dislocated patella has been performed in childhood by Pollard,[1] and in early infancy by Bajardi.[2]

The method described is that of Bradford.[3]

Elongation of the Ligamentum Patellæ.

In certain cases the ligamentum patellæ may be abnormally long so that the patella lies habitually above its proper position. This elongation may be one of the evidences of general relaxation of the ligaments of the knee, and thus a predisposing cause of the slipping patella, or of abnormal mobility at the knee joint.

Etiology.—The elongation of the tendon may be a congenital peculiarity or it may be acquired. It is often observed as an effect of anterior poliomyelitis, or of hemi- or paraplegia.

Symptoms.—The symptoms of elongation of the ligamentum patellæ, as distinct from those of the general laxity of the ligaments, that is often present, are weakness and disability, usually noticeable on walking up or down stairs, or after over-exertion. Shaffer, who first called attention to the disability, thinks that it may be a predisposing cause of displacement of the semi-lunar cartilages.[4]

Treatment.—In this, as in other forms of insecurity or of abnormal mobility at the knee, a brace that allows only antero-posterior motion, will, as a rule, relieve the symptoms. If the ligament is of such a length as to require it, it may be shortened, or the tubercle of the tibia may be removed and implanted at a lower point, as suggested by Walsham.[5]

Other Congenital Deformities at the Knee.

Congenital displacements are uncommon. As a rule they are incomplete and are caused by laxity of the ligaments and by defective formation of the bones or other parts.[6]

Snapping Knee.

A very slight form of partial recurrent displacement, is the snapping or clicking knee not uncommon in early infancy, in which the tibia on sudden extension of the limb springs forward, or rotates outward, on the femur, with an audible snapping sound. This movement appears to be the result of voluntary muscular contraction combined with laxity of ligaments. In some instances the subluxation appears to cause pain or discomfort. The ability to displace the tibia on the femur by muscular action, is sometimes found in older subjects.

[1] Lancet, 1891, Vol. I., p. 988.
[2] Archiv di Ortoped., 1894, p. 209.
[3] Trans. Am. Orth. Ass'n, Vol. VIII., p. 228.
[4] Ibid., Vol. XI.
[5] Med. Week, February 17, 1893.
[6] Drehmann, Die Cong. Lux. des Kniegelenks. Zeits. für Orth. Chir., Bd. 7, H. 4, 1900.

Treatment.—The treatment of congenital dislocations or subluxations of the knee consists in reposition, support and massage of the weak part. The snapping knee may be supported by a flannel bandage, or in the more marked type of laxity of ligaments, it may be fixed for a time in a brace. Complete recovery is the rule.

Congenital Contraction at the Knee.

Slight limitation of the range of extension of one or both knees is not infrequent. As a rule it is easily overcome by massage and manipulation. In the more extreme cases there may be an actual deformity of the femur, its lower extremity presenting a forward convexity, as in a case reported by Phocas.[1]

General Contractions.

Congenital contraction at the knees of a more marked and resistant form may be combined with flexion contraction at the hip, or it may be one of a series of contractions at other joints. In the latter instance, other congenital deformities or evidences of defective development are usually present. For example, certain joints may be fixed in flexion or fixed in extension. In some instances the contraction or the partial anchylosis appears to be due simply to long-continued fixation in utero, and non-development of the muscles. In others, it appears to be a complication of so-called fœtal rhachitis.

Treatment.—The treatment consists in regular massage and manipulation, with the aim of increasing the range of motion. Deformity, if present, may be rectified in the usual manner.

Prognosis.—The prognosis depends upon the cause of the contraction or fixation. In most instances, under careful and continued treatment, the range of motion may be in great degree restored.

Acquired Genu Recurvatum.

Synonym.—Back Knee.

Genu recurvatum, as the name implies, is a deformity in which the knee is habitually over-extended. The congenital form has been described. (See page 328.)

Etiology.—Acquired genu recurvatum may be a simple local deformity, or it may be secondary to weakness or distortion of other parts. Local or primary genu recurvatum may be an effect of rhachitis, or of disease or injury of the femur or tibia. In this form the femur may be curved sharply forward above the joint, or the upper extremity of the tibia may be bent backward at the epiphyseal junction, and flexion may be limited by the obliquity of the articulating surfaces.

More often the deformity is secondary. It may be, for example, an effect of equinus, either congenital or acquired, in which the knee is strained by the effort of the patient to place the heel upon the ground. It may be caused by the use of a traction brace in the treatment of hip

[1] Revue d'Orthopédie, January, 1899.

disease, when the knee joint is not properly supported. It is one of the comparatively infrequent complications of disease at the knee joint, in which the leg has been supported by the brace in an extended or over-extended position. In rare instances it is the direct result of traumatism, when the leg has been suddenly forced into an over-extended position, and the posterior ligaments, and possibly the crucial ligaments also, have been ruptured or weakened. It is most often, however, an accompaniment of paralysis of the posterior thigh group, or of the gastrocnemius muscle, or both.

In the majority of cases genu recurvatum is combined with a varying degree of knock knee. In many instances there is an abnormal mobility at the joint that allows a certain amount of posterior displacement of the tibia, and in extreme cases, there may be well-marked subluxation.

Symptoms.—The symptoms, aside from the deformity, are weakness and insecurity caused by the hyper-extension when weight is borne. If the deformity is extreme, the strain upon the weakened parts usually causes discomfort. Flexion is rendered difficult because of the abnormal relation of the joint surfaces and of the accommodative changes in the ligaments and muscles, so that in extreme cases the patient swings the leg along in the extended or over-extended position.

Treatment.—If the recurvatum is caused by deformity of the bones, the normal relations may be restored by osteotomy of the tibia or femur, as may be indicated. Deformity secondary to distortions elsewhere, may be treated by remedying the primary cause.

Traumatic genu recurvatum may be treated by fixation in the flexed position until the repair is complete, afterwards by massage and support, if necessary. The ordinary form of over-extended knee, combined with lateral mobility, must be supported by a brace which permits only antero-posterior motion to the normal limit or slightly less. Whenever possible, massage and exercises should be employed.

CHAPTER XI.

DISEASES AND INJURIES OF THE ANKLE JOINT.

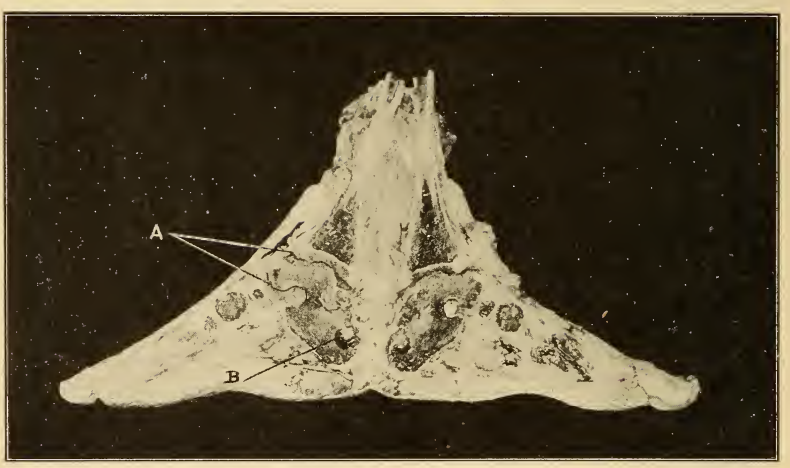
Tuberculous Disease of the Ankle Joint.

Disease of the ankle is the third in the order of importance, although it is far less common than is disease at the knee.

In five consecutive years, 1,788 cases of tuberculous disease of the joints of the lower extremity were treated at the out-door department of the Hospital for Ruptured and Crippled. In 54.1 per cent. of these the hip joint was affected, in 36.2 per cent. the knee joint, and in but 9.7 per cent. the ankle joint.

Pathology.—The pathology of tuberculous disease at the ankle differs in no essential particular from that of disease of the hip and knee.

Fig. 233.



Tuberculous disease of the ankle and tarsus. A, disease of the ankle and sub-astragaloid joints; B, cavity in the os calcis containing sequestrum.

It does not therefore call for special consideration. It is of interest to note however, that abscess is a more common complication at this, than at the other joints.

In 30 final results of disease at the ankle reported by Gibney,[1] abscess was present in 25, 83 per cent. In 78 final results reported by Prendlsburger [2] abscess was present in 68, 87 per cent., as contrasted with a percentage of 69 and 51 at the knee and hip respectively. This greater liability to abscess is very possibly apparent rather than actual, since the ankle joint is so superficial that fluctuation may be detected

[1] Am. Jour. Obstetrics, April, 1880. [2] Loc. cit.

here that would be overlooked at the hip. And because the tissues about the joint readily allow spontaneous opening at an early stage, before sufficient time has elapsed to permit of spontaneous absorption, that is so common in disease of the spine and hip.

Situation of Disease.—Otto Hahn[1] has recently investigated the cases of tuberculous disease of the ankle and foot treated at Tübingen during the past fifteen years. These cases were 704 in number in 685 patients, in 19 both feet having been involved.

In 309 of the cases the disease was of the ankle joint. Of these 51 per cent. were osteal in origin. The primary focus was in the internal malleolus in 11, the external in 7, in both in 5. It was in the astragalus in 116 cases.

In 16 instances the disease of the ankle was secondary to primary infection of the os calcis, and in 5 cases both the astragalus and the os calcis were diseased.

Etiology.—The etiology of tuberculous joint disease does not require further comment. It may be noted, however, that tuberculous disease at the ankle is relatively more common in later childhood and adult life than is the same affection at the knee and hip.

Of 1,000 cases of disease of the hip joint, 12 per cent. were in patients more than 10 years of age.

Of 1,000 cases of disease of the knee joint, 25 per cent. were in patients more than 10 years of age.

Of 339 cases of disease of the ankle joint, 30 per cent. were in patients more than 10 years of age.[2]

Age at Incipiency of Ankle-Joint Disease in 339 Consecutive Cases Treated at the Hospital for Ruptured and Crippled.

1 year or less	5	23 years old	2
2 years old	42	24 " "	2
3 " "	43	25 " "	3
4 " "	44	26 " "	3
5 " "	34	27 " "	4
6 " "	24	28 " "	4
7 " "	19	29 " "	2
8 " "	8	30 " "	2
9 " "	9	31 " "	0
10 " "	9	32 " "	1
11 " "	11	33 " "	2
12 " "	8	34 " "	1
13 " "	4	35 " "	0
14 " "	4	36 " "	2
15 " "	4	37 " "	2
16 " "	6	40 " "	4
17 " "	2	43 " "	1
18 " "	4	44 " "	1
19 " "	3	45 " "	4
20 " "	3	46 " "	2
21 " "	4	48 " "	1
22 " "	5	50 " "	1
			339

[1] Beiträge zur Klin. Chir., Bd. 26, H. 2, 1900.

[2] Statistics from Hospital for Ruptured and Crippled.

Of the 339 patients 177 were males (52.2 per cent.); 162 were females (47.8 per cent.). The disease was of the right ankle in 173 cases; of the left in 166.

AGE OF THE PATIENTS TREATED FOR ANKLE-JOINT AND TARSAL DISEASE AT TÜBINGEN. (HAHN.)

	Males.	Females.	Total.
1 to 10 years	45	28	73
11 " 20 "	149	91	240
21 " 30 "	89	34	123
31 " 40 "	32	28	60
41 " 50 "	37	27	64
51 " 60 "	35	26	61
61 " 70 "	18	11	29
71 " 80 "	6	1	7
81 "	1	0	1
	412	246	658

Of 658 patients 412 were males (62 per cent.); 246 were females (38 per cent.). In 27 the sex was not stated.

Symptoms.—The symptoms are usually subacute in character, and are often mistaken for sprain or rheumatism. In some instances they

FIG. 234.

Tuberculous disease of the ankle.

appear to follow an injury, but in the majority of cases in childhood no cause can be assigned. The ankle becomes sensitive to sudden movements, the patient limps, discomfort after over-use and pain at night

become noticeable. The limp differs in character from that caused by hip or knee disease. The patient walks with the foot rotated outward, bearing the weight upon the heel and upon the inner border, all active leverage being avoided.

DEFORMITY.—The primary deformity of ankle-joint disease, in the subacute cases, is valgus, induced apparently by the continued use of the limb in the passive attitude. In more advanced cases it becomes equino-valgus and when the limb is no longer capable of supporting weight, but is held pendant, the equinus deformity predominates, due partly to the force of gravity and partly to the muscular spasm.

As has been stated, in the early stage the symptoms are those of a

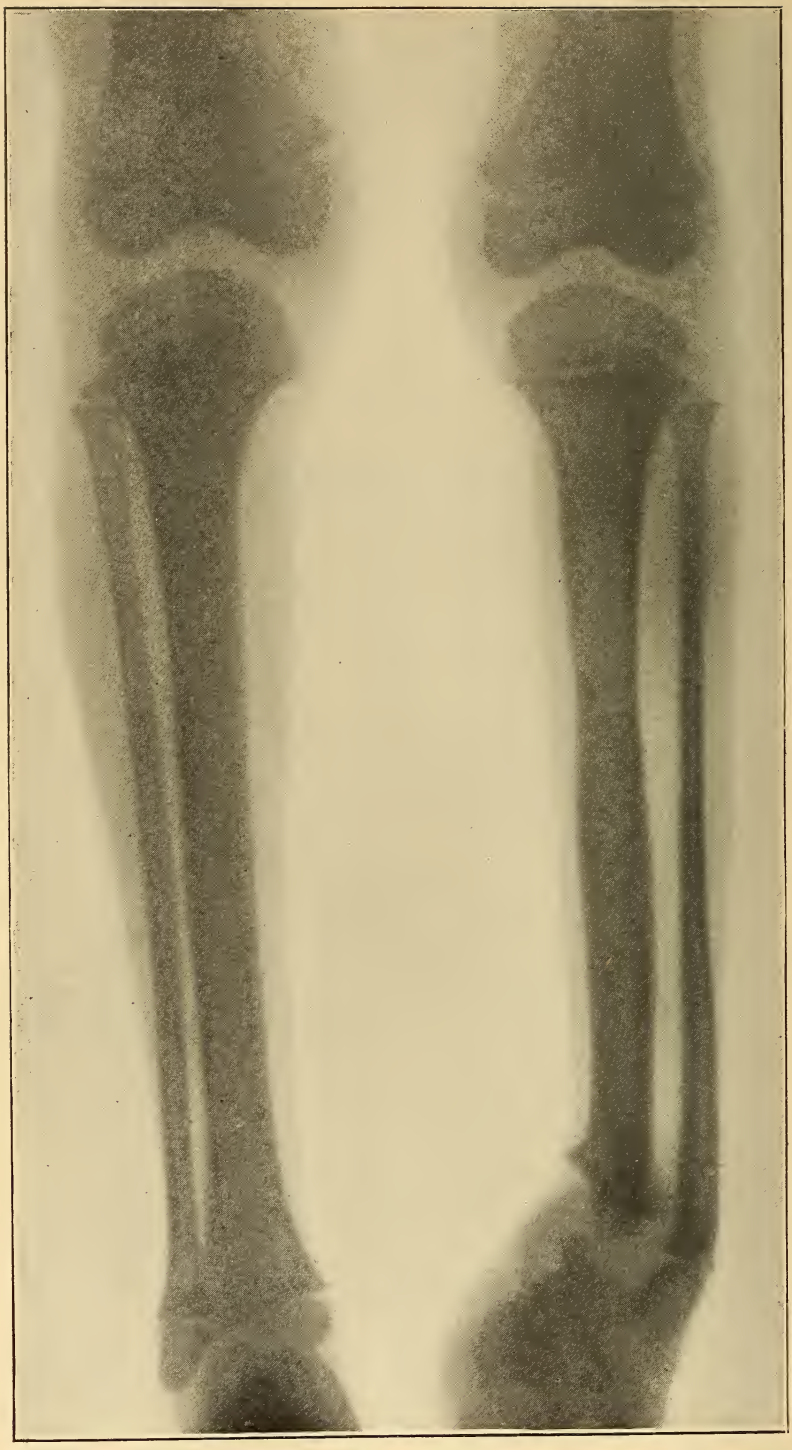
FIG. 235.

Tuberculous disease of the sub-astragaloid joint.

persistent, somewhat painful disability at the ankle, causing **stiffness, limp** and at times **pain**; later **swelling** and **deformity** appear.

Physical Examination.—The joint is usually somewhat enlarged. In some instances the swelling is uniform, in others it is localized in front or behind one of the malleoli. This swelling is not, as a rule, like that of simple effusion into the joint, but the tissues have the peculiar elastic characteristic of thickening and infiltration. There is usually a perceptible increase in the local temperature, and pressure directly upon the malleoli causes discomfort. The voluntary movements of the joint are restricted and passive movements show the characteristic reflex muscular spasm, limiting both dorsal and plantar flexion.

FIG. 236.



The epiphyses of the lower extremities at the age of six years, showing the effect of operative removal of bone at the ankle joint for tuberculous disease at the age of 3 years, in causing subsequent deformity of the foot and shortening of the limb.

Sub-astragaloid Disease.—If the astragalus is primarily diseased, the symptoms are usually first apparent in the ankle joint, but in certain cases the joint between the astragalus and the os calcis is first involved, although this is more often the effect of primary disease of the os calcis. Disease at the sub-astragaloid joint is usually classed as ankle-joint disease, although the swelling is most marked at a point somewhat below the malleoli. (Fig. 235.) Forced lateral motion of the os calcis causes discomfort, and the range of adduction and abduction of the foot is restricted, while dorsal and plantar flexion may remain completely free.

Diagnosis.—The principles of differential diagnosis of tuberculous disease from other affections have been considered in detail in the description of disease of the spine and of the larger joints.

In childhood, a chronic, painful disease confined to a single joint in which motion is limited by muscular spasm, and in which there is a tendency to deformity, is almost certainly tuberculous in character.

In adult life also the same principle applies, and distinguishes tuberculous disease from **rheumatism, rheumatoid arthritis** or other general affections. Forms of **infectious arthritis** may be differentiated by the history. **Sprains** or other injury may be distinguished by the history of the onset and by the absence of local signs of serious disease. In rigid **flat foot** the symptoms are localized at the medio-tarsal joint. It should be borne in mind, also, that the pain from a weak or injured foot is experienced as a rule only when it is in use, whereas in tuberculous disease of the bone, pain is common when the part is not in use, and it may be particularly troublesome at night.

Treatment.—In disease of this as of other joints functional rest is indicated. This necessitates fixation and stilting of the limb, efficient traction being manifestly impossible. The foot should be fixed in a light plaster bandage, extending from the extremities of the toes to the calf, at a right angle with the leg and in an attitude of slight supination, in order to guard against the tendency toward valgus. This deformity is very common after the cure of the disease and it often subjects the patient to the additional discomfort of progressive flat foot.

Reduction of Deformity.—If the foot has become distorted before the patient is brought for treatment, the plaster bandage may be applied in the attitude of deformity, and at the subsequent applications of the dressing, when the muscular spasm is lessened, gentle manipulation will gradually overcome the malposition. Although in resistant cases immediate reduction of the deformity under anæsthesia may be required. Throughout the entire course of treatment the greatest attention must be paid to the attitude. Deformity is easily prevented, but it is often very difficult to correct, especially during the later stages of the disease, when the tissues are infiltrated and sensitive, and when discharging sinuses are present.

Other retentive appliances may be employed, but they are inferior to a properly applied bandage which holds its place by accuracy of adjustment, which most effectively prevents motion, and which exercises

a certain degree of compression upon, and general support of, the swollen joint. The bandage is renewed at intervals of a month, or longer if it is properly protected by a light shoe or slipper.

The most satisfactory brace to serve as a stilt in connection with the local support is the Thomas brace, which has been described in the section on disease of the knee joint. (Fig. 229.)

When patients are treated efficiently the discomfort or inconvenience attending the disease is slight. As a rule, the swelling of the joint becomes more localized and finally an abscess appears beneath the skin. It is then advisable to remove the fluid and other contents, by means of a simple incision. In most instances a sinus persists for a time. If the discharge is slight, the part may be dressed with ichthyol, balsam of Peru or other application, and the whole inclosed again in the plaster bandage; or, if it be more profuse, an opening may be made and the dressing applied outside the plaster bandage.

Operative Treatment.—Early operation, especially gouging operations, should be avoided. An effective operation of this character often involves the sacrifice of bone that would be spared in the natural cure, thus it entails an irregularity in the growth, and causes deformity in after life, which may be irremediable. (Fig. 236.)

Similar operations in the treatment of fistulæ, or abscess, while the tissues are thickened and œdematous, and while the disease within the joint is active, should be postponed until the process of repair is more advanced. During the stage of convalescence, however, cure may be hastened by the removal of persistent foci of disease, or sequestra in the bone, or tuberculous tracts in the overlying soft parts.

In the adult or adolescent, and in exceptional cases in childhood, operative removal of the disease may be indicated, and if it is confined to the ankle joint, the removal of the astragalus, which is usually the primary seat of infection, is the operation of choice.

The operation is performed under the Esmarch bandage; a curved lateral incision is made passing beneath the external malleolus from the neighborhood of the tendo-Achillis to the anterior aspect of the joint. The peroneii tendons and the lateral and capsular ligaments are divided, after which the foot may be displaced inward, exposing the joint, the ligament between the astragalus and the os calcis having been separated, the bone may be removed with a little manipulation; after which all the diseased tissue in the soft parts and in the bone must be removed thoroughly. If the disease has not extended to the tarsus, and if it seems to have been completely removed, the wound may be closed after the peroneii tendons are sutured, but in most cases it should be packed, for a time, with gauze. The after-treatment is conducted as if the operation had not been performed; support and fixation being continued until it is evident that the disease is cured.

Removal of the astragalus does not interfere to a marked extent with the function of the foot, nor does it cause noticeable deformity. As a primary operation, permitting inspection and the opportunity for thorough removal of all disease in the neighboring parts, it should

always be performed in preference to extensive gouging, which is, as a rule, of little avail.

Prognosis.—Disease at the ankle is not only less common but it is less dangerous than that of the larger joints, because it is remote from important structures and because there is less opportunity for the burrowing of infected abscesses. The duration of the disease here, is, as a rule, shorter than at the knee or hip, and the final results in childhood, are almost always excellent. Often free motion is retained, and even if the astragalus be fixed by disease, the mobility in the other joints of the foot is sufficient to compensate very effectively for the anchylosis. Shortening of the limb is of comparatively little consequence. It is not often more than an inch, and it may be absent. The growth of the foot is retarded partly from disease, and partly because of the destructive effect of the disease upon the tarsal bones.

In the 30 cases reported by Gibney, treated expectantly, in which the mechanical treatment was far from effective, 6 patients recovered with normal motion; 11 with practically normal function. In 7 there was good motion. In 6 there was anchylosis, and in 3 persistent valgus. In all, the limb was efficient. In 20 instances there was no limp, and in but one case was it marked. In no instance was a crutch, cane or other support used. The average duration of the disease was 3 years and 3 months, a minimum of 1 year, a maximum of 6 years. There were 2 deaths, of which but 1 was dependent upon the disease, septicæmia being the cause assigned, though it is stated that practically all the bones of the tarsus were involved. In this case amputation was evidently indicated.

Tuberculous Disease of the Tarsus.

Tuberculous disease of the joints of the foot, not involving the ankle, is not uncommon.

In 386 of the 704 cases reported by Hahn, the disease was limited to the foot. In 141 cases the medio-tarsal joint was involved, in 51 of these the disease was confined to this joint; in 46 the ankle was involved; in 29 the disease extended forward to the tarso-metatarsal articulation, and in 16 the three joints were diseased. In 78 cases the tarso-metatarsal joint was involved, in 33 of which the disease did not extend beyond this articulation.

Disease of Individual Bones.—In these cases the distribution was as follows:

The astragalus	170	disease confined to the single bone in 8
The calcaneum	200	" " " " " " 87
The cuboid	116	" " " " " " 18
The scaphoid	82	" " " " " " 2
The cuneiform bones	86	" " " " " " 8
Metatarsal bones	45	in one-half of these the disease was of the 1st metatarsal, either alone or in connection with the adjoining cuneiform bone or phalanx.

In a total of 1,231 cases, including these and others reported by Audry,[1] Koenig,[2] Mondan,[3] Münch,[4] Spengler,[5] Vallas,[6] Czerny[7] and Dumont,[8] the relative frequency of the disease in the bones of the foot and ankle appeared to be as follows:

Malleoli.....	96, 7.7 per cent.	Scaphoid.....110,	8.9 per cent.
Astragalus.....291,	23.6 "	Cuneiform bones 109,	8.8 "
Calcaneus.....339,	25.9 "	Metatarsus.....110,	8.9 "
Cuboid.....154,	12.5 "	Phalanges..... 22,	1.7 "

Primary Disease of the Astragalo-scaphoid Joint.—In disease at this point the swelling is localized in front of the ankle on the inner side of the foot. Adduction is restricted and the foot is often fixed in an attitude of persistent abduction.

Disease of other bones of the tarsus is indicated by the local swelling and sensitiveness. The disease sometimes involves the shaft of a metatarsal bone, or one of the phalanges, causing expansion and destruction, "spina ventosa." (See page 356.)

Treatment of Tarsal Disease.—Disease of the tarsus shows a marked tendency to extend from one bone to another until the entire foot is involved. Consequently if an early diagnosis is made of a distinctly localized process, prompt removal of the diseased bone is indicated. But in most instances the disease is too extensive to permit of its radical removal. In such cases operative intervention is contraindicated, and the treatment by protection, similar to that employed in disease of the ankle, is indicated. In childhood the prognosis is very good even when the disease is extensive, but in adult life amputation of the foot may be advisable, especially if there be co-existent disease of the lungs.

Sprain of the Ankle.

The ankle is, from its position, especially liable to injury, in fact the term "sprain" is popularly associated with this joint.

A sprain is most often caused by an unguarded movement, by which the foot is turned suddenly inward or outward, with sufficient force to rupture some of the fibers of the muscles, to strain tendons and tendon sheaths and even to rupture ligaments. If the foot is twisted inward, the injury is most marked on the outer side of the joint; if outward, on the inner side of the ankle. In the slighter degrees of sprain, the injury may be confined to the tissues about the joint, but in most instances there is effusion within the capsule, even hemorrhage when the injury has been severe.

Symptoms.—The immediate symptoms of sprain are pain, often intense, of a throbbing character, swelling, heat and in many instances,

[1] Revue de Chir., 1891.
[2] Schmidt's Jahrb., Bd. 204, 1884.
[3] Deutsche Chir., L. 66.
[4] Deutsche Zeits. f. Chir., Bd. 11, 1879.
[5] Ibid., Bd. 44, 1897.
[6] Deutsche Chir., L. 66.
[7] Volk. S. klin., V., No. 76.
[8] Deutsche Zeits. f. Chir., Bd. 17, 1882.

discoloration of the surrounding parts, even extending over the leg and foot.

Treatment.—If an opportunity for immediate treatment is offered, the swelling and the effusion of blood may be restrained by the application of elastic stockinette bandages, from the toes to the knee. As much compression is exercised as the comfort of the patient will allow, and the bandage should be made sufficiently thick to prevent painful motion. If the injury has been severe and if the part is very sensitive to motion or jar, the joint having been protected with cotton may be fixed in a light plaster bandage. This may be cut down the front to allow for daily massage of the foot, ankle and leg which is of great service in hastening the absorption of the effusion.

The use of hot air, hot and cold water and static electricity, and the like, are of service also in relieving the discomfort and especially in stimulating the circulation of the blood, upon which repair depends.

FIG. 237.

Adhesive plaster strapping applied for sprain of the ankle.

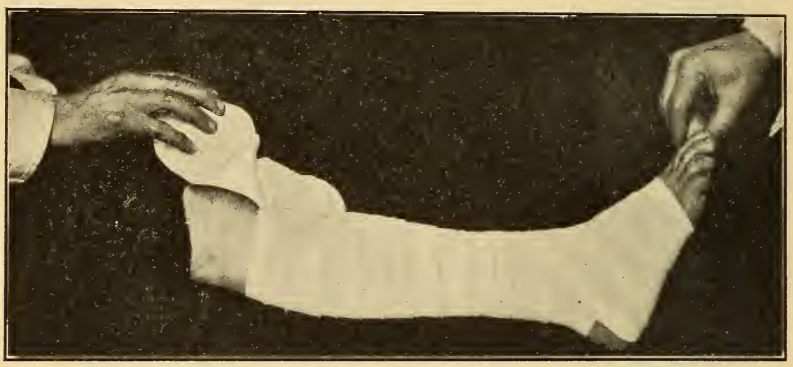
By far the most effective treatment during the stage of recovery and as an immediate application for sprains of slighter degree, is the adhesive plaster strapping which has been popularized by Gibney. The plaster may be applied in a variety of ways; a satisfactory method is as follows.

One end of a strip of adhesive plaster about three feet long and three inches wide, is applied to the lateral aspect of the leg just below the knee joint; it is carried down the side of the leg over the malleolus, beneath the heel and arch, and up the other side to a point opposite the beginning, where it is fixed by a circular band about the calf. If the sprain is of the outer side of the ankle, sufficient tension is made upon the outer half of the plaster to hold the foot slightly abducted. If, as is more common, the sprain is of the inner side, the inner half is drawn firmly beneath the arch, carrying the foot toward inversion so that all strain may be removed from the sensitive part. This band of

plaster is reinforced by one or more so that the lateral aspect of the ankle is completely covered. And in addition the entire ankle, with the exception of the heel, is then enclosed with narrow overlapping strips, which cover all the tissues, well beyond the sensitive area. The foot and leg are then bandaged to assure the adhesion of the plaster. When the joint is firmly held by the supporting plaster, the patient can, as a rule, walk with comfort; and he is encouraged to do so, for functional use, provided it does not cause additional injury, is the most effective stimulant of the circulation; thus the patient applying, as it were, an automatic massage, cures himself.

As the swelling subsides the plaster strapping wrinkles, and it must be renewed, about three applications being required as a rule, the last of which is allowed to remain until all of the symptoms have disappeared. It is perhaps needless to state that a preliminary shaving of the part will add somewhat to the comfort of the patient. Gibney advises the use of narrow, overlapping strips and does not cover the front of the ankle; the manner of application is, however, of little importance provided that the sensitive part is efficiently supported and compressed.

FIG. 238.



The stockinette bandage.

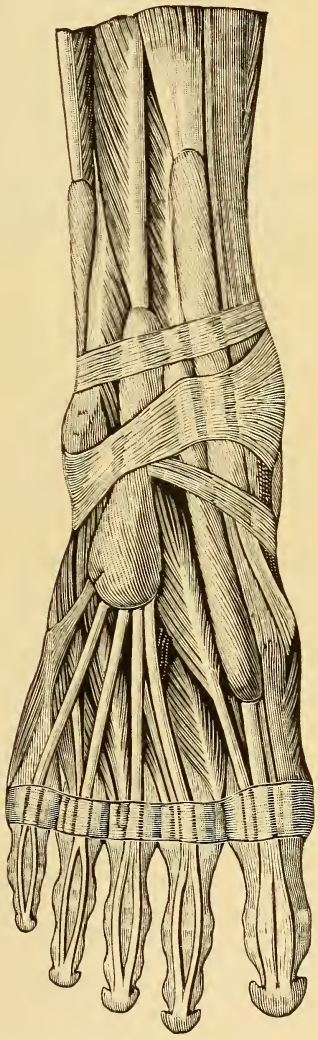
CHRONIC SPRAIN.—A chronic sprain may be the result of an inefficiently treated acute injury, in which an improper attitude originally assumed to spare the sensitive part, finally becomes habitual. In other instances, persistent disability may be the result of fixation of the joint for too long a time in splints. Such disuse causes atrophy of the muscles, while the effused material within and without the joint remains because of the imperfect circulation. The same disability may follow simple disuse of the injured part. It is more often observed in nervous individuals who exaggerate the importance of the injury and the discomfort that it causes. In such cases the limb may be discolored by venous congestion, the foot may be œdematous and the movements may be limited by adhesions or by muscular adaptation to the habitual attitude.

In other instances the original injury may have caused a slight subluxation of the astragalus, sufficient to throw the foot into an attitude of abduction, in which it has become fixed by the secondary changes in the muscles and ligaments. In some cases of this class the original sprain was at the medio-tarsal or at the sub-astragaloid joint, and its effect has been a traumatic weak foot. Finally, many of the so-called sprains of the ankle are simply injuries of a weak foot and are examples of the rigid or inflamed weak or flat foot. (See the Weak Foot.)

Treatment. — Treatment must be conducted with the aim of restoring the normal range of motion and so supporting the part that normal functional use may be permitted. In many instances when adhesions have formed, and when the foot is persistently held in an abnormal attitude, forcible manipulation under anæsthesia may be required as a preliminary treatment followed by fixation for a time in a plaster bandage, in the attitude directly opposed to that which had been habitual. And as in this class of cases the habitual attitude is usually one of equino-valgus, the foot should be fixed for a time in a plaster bandage in a position of extreme varus, and upon it the patient is encouraged to bear his weight both in standing and walking. When all discomfort has disappeared, a support, usually a light leg brace to prevent lateral motion, and if the arch is depressed a foot plate also, should be worn for a time. The most effective curative agent is functional use, but massage, hot air, passive manipulation and exercises are of service also.

Injuries of this class are very amenable to treatment, conducted with the aim of restoring normal function, when proper support is provided during the period of pain and weakness.

FIG. 239.



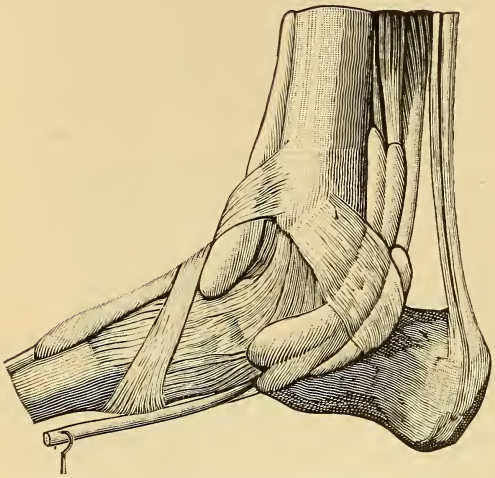
The anterior annular ligament of the ankle and the synovial membranes of the tendons beneath it artificially distended. (TESTUT.) (From Gerrish's Anatomy.)

Teno-Synovitis.

The sheaths of the tendons about the ankle joint, if involved in a sprain of the ankle, may cause persistent interference with function; or strain of

a tendon and of its sheath may cause symptoms of disability when the joint is uninjured. The symptoms of acute teno-synovitis are discomfort on motion of the affected tendon and this motion may be accompanied by a peculiar creaking which is apparent on palpation. In many instances there is slight local swelling and sensitiveness to pressure about the affected part, and the general movements of the foot that call the muscle into action are painful.

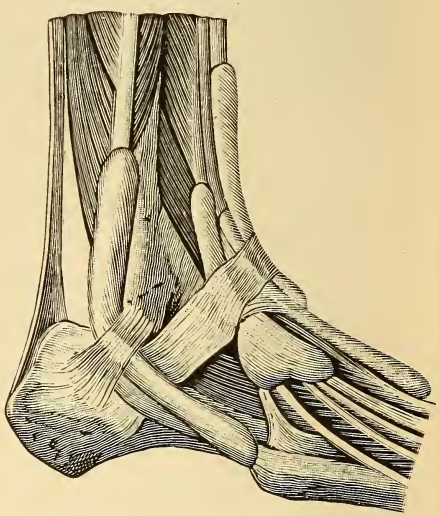
FIG. 240.



The internal annular ligament of the ankle and the artificially distended synovial membranes of the tendons which it confines. (TESTUT.) (From Gerrish's Anatomy.)

The arrangement of the tendon sheaths should be borne in mind. At the ankle joint all the tendons are provided with sheaths; on the front of the foot are three—the sheath of the tibialis anticus, which extends from a point about two inches above the extremity of the malleolus to the scaphoid bone (Fig. 239); that of the extensor longus pollicis, from the annular ligament to the head of the first metatarsal, and the common sheath for the extensor communis digitorum extending from a point about half an inch above the malleoli to about one inch below the annular ligament. Behind the internal malleolus are the common sheaths of the tibialis posticus and flexor longus digitorum, beginning about an inch above the extremity of the malleolus and extending to the astragalo-scaphoid junction and that of the flexor longus pollicis of about the same extent. (Fig. 240.) Behind the outer malleolus is the sheath of the two peroneii, beginning one inch above the malleolus, dividing into two portions for the two tendons and ending just behind the tuberosity of the fifth metatarsal bone. (Fig. 241.)

FIG. 241.



The external annular ligament of the ankle and the artificially distended synovial membrane of the tendons which it confines. (TESTUT.) (From Gerrish's Anatomy.)

Treatment.—Simple traumatic teno-synovitis should be treated by rest and by compression. An effective treatment is strapping by adhesive plaster, so applied as to prevent the movements of the foot that cause discomfort. In more painful and persistent cases the use of a plaster bandage to assure absolute rest may be necessary. Cautery applied over the affected part is of service. Chronic teno-synovitis may follow injury or it may be the result of gonorrhœa or other infectious disease. In chronic cases when the palliative treatment is ineffective, thorough removal of the affected sheath is indicated.

Tuberculous Teno-synovitis.—A persistent and increasing swelling of a tendon sheath always suggests tuberculous disease. In such instances the sac is thickened and often contains the so-called rice bodies. Prompt and complete removal of the diseased sheath is indicated and by this means a permanent cure may be attained in most instances.

Other Affections of the Ankle Joint.

The ankle joint may be the seat of an infectious arthritis; it may be involved in an osteomyelitis of the tibia. It may be one of the joints affected in chronic rheumatism or rheumatoid arthritis, and occasionally Charcot's disease may appear in this situation. The principles of the treatment of these affections have been indicated elsewhere.

CHAPTER XII.

DISEASES AND INJURIES OF THE ARTICULATIONS OF THE UPPER EXTREMITY.

Tuberculous Disease of the Shoulder Joint.

Disease of the shoulder is very uncommon in childhood. In a total of 453 cases of tuberculous disease treated at the Vanderbilt Clinic 210 were cases of Pott's disease. In 6 of the remaining 243 cases, the disease was of the shoulder joint (2.5 per cent.).

In 1,883 consecutive cases of joint disease—Pott's disease being excluded—treated in the Out-patient Department of the Hospital for Ruptured and Crippled during the past five years, the shoulder joint was involved in 38 instances (2 per cent.). In 1,900 cases of joint disease treated at Billroth's Clinic, the shoulder was involved in 14, or less than 1 per cent.

Fig. 242.

Section of the shoulder joint, in childhood. (Schuchardt.)

Pathology.—The disease usually begins in the head of the humerus. In 32 observations on adults recorded by Mondan and Andry,[1] the primary disease was of the head of the humerus in 23 cases, of the humerus and scapula in 4, of the scapula alone in 1 and in 3 instances it appeared to be primarily synovial.

In the majority of cases abscess forms and comes to the surface near the insertion of the deltoid muscles. In advanced cases the tissues of the axilla and of the adjoining thorax may be infiltrated and perforated by numerous sinuses. In other instances the disease is of the form

[1] Revue de Chir., 1892.

called caries sicca, in which there is no swelling, but progressive destruction of the head of the humerus by granulation tissue. This form is characterized by extreme muscular atrophy and by practical anchylosis.

Statistics.

AGE AT INCIPIENCY OF DISEASE AT THE SHOULDER JOINT IN 62 CONSECUTIVE CASES TREATED AT THE HOSPITAL FOR RUPTURED AND CRIPPLED.

1 year or less	1	13 years old	3
2 years old	6	15 " "	2
3 " "	1	18 " "	3
4 " "	3	19 " "	5
5 " "	3	20 " "	4
6 " "	1	23 " "	1
7 " "	3	26 " "	2
8 " "	4	27 " "	1
9 " "	6	34 " "	1
10 " "	1	48 " "	1
11 " "	5	56 " "	1
12 " "	4	Total	62

Males 38, females 24; right 35, left 27.

Townsend[1] made a detailed report on 21 cases treated at the Hospital for Ruptured and Crippled during the years 1889 to 1893. Ten of these were less than ten years of age, 7 were between ten and twenty, and 4 were more than twenty. The youngest patient was three and a-half and the age of the oldest was thirty-five years. In 5 cases the disease was secondary to disease of other parts; in one case to Pott's disease, in 2 to hip disease and in 2 to disease of the knee joint.

Symptoms.—The history of the case will show the persistent and progressive character of the disability, but the symptoms, characteristic of tuberculous disease, are far less marked at the shoulder than at other joints. This is explained by the fact that the upper extremity is not subjected to the strain of weight-bearing and because the mobility of the scapula upon the thorax lessens the injury caused by unguarded movements of the arm. This double joint at the shoulder masks the interference with the function of the joint, and even when absolute anchylosis is present the patient may think that the movements are but moderately restricted. Finally, the traumatism caused by over-use may be lessened by the voluntary restraint that the patient may exercise upon motion at this joint, without greatly inconveniencing himself.

The symptoms of the disease may be classified as **pain, sensitiveness, restriction of motion, atrophy.**

The pain is usually of a dull aching character with occasional neuralgic pain referred to the elbow and arm. The discomfort is increased by movements that pass beyond the limits allowed by the mobility of the scapula, especially on attempting to rotate the humerus, as in clothing oneself or brushing the hair. The joint is sensitive to pressure, thus the patient finds that he can not lie on the affected side at night.

[1] Trans. Am. Orth. Ass'n, Vol. VII.

On physical examination the limitation of motion caused by muscular spasm will be evident when the scapula is fixed, so that movement of the joint can be tested. Normally the range between adduction and abduction is about 90 degrees, and between flexion and extension it is somewhat less than this.

Pressure upon the head of the humerus usually causes pain, and in many instances local heat and swelling are present. The atrophy of the shoulder muscles is often extreme and that of the other muscles of the limb is well marked.

As has been stated, abscess is a common accompaniment of the disease, and in such cases the tissues about the joint are swollen and infiltrated. In other instances there is progressive destruction of the head of the humerus without abscess formation (Caries sicca). In cases of this type the flattening of the shoulder may be so extreme as to be mistaken for sub-coracoid dislocation.

Treatment.—The treatment of the disease here as elsewhere is rest. To assure absolute functional rest the wrist should be attached to the neck by a sling, the elbow being flexed to an acute angle; the arm is then fixed to the thorax by a bandage and all the clothing, including the shirt, is placed outside the affected part. Local rest and compression may be still further assured by strips of adhesive plaster applied over the shoulder and extending to the back and chest; or a shoulder cap of leather or plaster may be employed. This method of fixing the arm is the only one that assures continuous rest, as a change of the clothing necessitates movement of the joint, which causes discomfort and retards the cure. During the acute phases of the disease, the arm may be supported in the attitude of extreme abduction by means of a triangular splint or pad. This position is often that of greatest comfort to the patient. Direct traction is not often employed, as support of the pendant limb is usually preferred by the patient.

Operative Treatment.—If the focus of disease seems to be localized, an exploratory operation for its early removal may be indicated. Excision of the joint in the adult cases, or arthrectomy in younger subjects, may be advisable when suppuration is persistent or when for other reasons it may seem best to attempt to remove the diseased area.

Prognosis.—The duration of the disease appears to be from two to five years. The death rate is higher than in disease of the joints of the lower extremity, because a larger proportion of the patients are adults and in this class tuberculosis of the lungs is not an infrequent complication.

It is impossible to speak positively of the results of the conservative treatment of disease of the shoulder. The disease is uncommon and protection is almost never applied in the early stage, nor efficiently or persistently employed to the end. The ordinary result is therefore anchylosis, usually of the fibrous rather than of the bony variety.

If the disease appears in early life the growth of the limb may be seriously interfered with; an inch or more of shortening from this cause is not uncommon.

Tuberculous Disease of the Elbow Joint.

Tuberculous disease of the elbow joint is the fourth in order of frequency, preceding the shoulder and the wrist. Of 1,883 consecutive cases of joint disease treated at the Hospital for Ruptured and Crippled, 56 were of the elbow.

Pathology.—The primary disease is in most instances osteal, as in 92.8 per cent. of the cases investigated by Scheimpflug, 44 in number.[1] The original focus of infection is somewhat more often of the ulna than of the humerus. Of the ulna the olecranon process, and of the humerus the external condyle, appear to be the points of election. Disease of the head of the radius is comparatively infrequent. In 119 cases reported by Ollier, the olecranon was involved in 73, the humerus in 33 and the radius in 12 instances.[2] And in the cases investigated by Kummer,[3] and Middledorpt,[4] the ulna was more often the seat of the primary disease than was the humerus, but in 81 cases treated in Koenig's clinic the primary disease was of the humerus in 43, of the olecranon in 36 and of the radius in 2 instances.[5]

Statistics.

AGE AT INCIPIENCY OF DISEASE AT THE ELBOW JOINT IN 59 CONSECUTIVE CASES TREATED AT THE HOSPITAL FOR RUPTURED AND CRIPPLED.

1 year or less	2			11 years old	1		
2 years old	5			13 " "	3		
3 " "	8			14 " "	2		
4 " "	5			15 " "	1		
5 " "	5			17 " "	1		
6 " "	4			19 " "	1		
7 " "	8			21 " "	1		
8 " "	1			23 " "	1		
9 " "	2			25 " "	2		
10 " "	5			29 " "	1		
				Total	59		

Males 28, females 31 ; right 27, left 32.

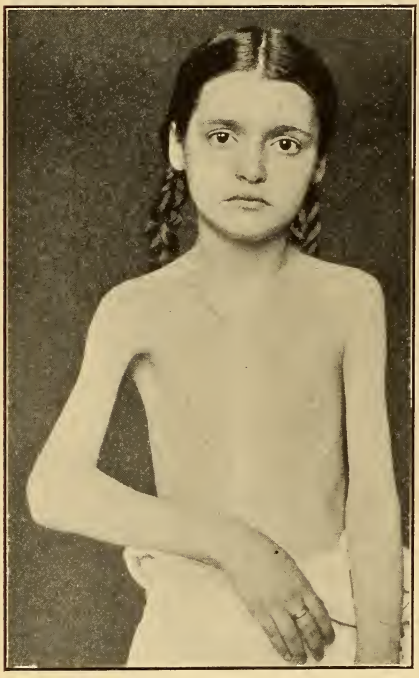
Symptoms.—The symptoms are those of a chronic, persistent, destructive disease. **Pain, local sensitiveness and swelling, stiffness, deformity, atrophy.**

The pain is usually localized at the elbow. It is increased by sudden movements, and as the bones are so superficial there is usually local sensitiveness to pressure, most marked over the seat of the disease. In the early stage the swelling is slight and it is of the peculiar elastic character due to thickening of the tissue, rather than to effusion within the capsule, but as the disease progresses the joint assumes the peculiar spindle shape characteristic of white swelling. The degree of elevation of the local temperature depends upon the activity of the

[1] Festschrift für Billroth, 1892.
[2] Karewski, Chir. Krank. des Kindersalters, p. 268.
[3] Deutsche Zeits. f. Chir., Bd. 27.
[4] Archiv f. Klin. Chir., Bd. 33.
[5] Koenig, Lehrbuch Spec. Chir., Berlin, 1900.

disease. The most important physical sign is the restriction of motion due to the characteristic muscular spasm which becomes evident when the limit of painless motion is passed. The limitation of extension and flexion gradually increases and finally the limb becomes fixed in an attitude midway between flexion and extension, with the forearm in an attitude midway between pronation and supination. This is the characteristic deformity of the disease.

FIG. 243.



Tuberculous disease of the elbow joint.

Atrophy of the muscles of the arm and forearm is present, corresponding to the intensity and duration of the disease and to the functional disability of the joint.

Treatment. — The treatment here, as elsewhere, consists essentially in placing the joint at rest in the attitude at which anchylosis or limitation of motion will least inconvenience the patient, and at the elbow joint, this is practically at right-angular flexion. (Fig. 244.)

In the treatment of young children the wrist may be attached closely to the neck by means of a sling, with the elbow at an acute angle (the Thomas method) within the clothing. Or a light plaster bandage may be used to fix the joint, together with the sling. This enables the patient to dress himself without moving the part and it protects the joint from injury. Other forms of splints may be employed, but the plaster bandage answers every purpose. It should, of course, extend from the axilla to the hand, and in sensitive cases it may include the hand also.

REDUCTION OF DEFORMITY.—In many instances the arm is fixed in the semi-extended attitude when the patient is brought for treatment. In this class of cases a simple and effective means of reducing deformity is that suggested by Thomas. When it is impossible to bring the wrist to the neck, one bends the neck toward the wrist and attaches the two by a bandage that the patient is unable to remove. From this uncomfortable attitude the patient can free himself only by drawing the arm toward the neck and thus reducing the deformity. At the next visit the same procedure is repeated, until finally the elbow is flexed to the required degree. A permanent sling may be constructed of a leather wrist band and a tube of leather to pass about the neck, through which

the bandage may be drawn; thus the pressure on the wrist and neck may be lessened. In the very resistant cases reduction of deformity under anæsthesia may be required, but this is not often necessary.

Prognosis.—If the case is treated at an early stage the prognosis in childhood is good. The duration of treatment may be estimated at two years or more and retention of a fair range of motion may be expected. Anchylosis in the right-angled position does not, however, seriously inconvenience the patient, provided the cure is absolute. The loss of growth is less than when the epiphysis at the shoulder is destroyed and the final disproportion in size depends, of course, upon the age of the patient and upon the degree of function that is preserved.

FIG. 244.

Tuberculous disease of the elbow joint, the stage of recovery.

Operative Treatment.—In some instances it is possible to remove small foci of disease from the humerus, or from the ulna, before the joint is involved. The position of the disease may be indicated by sensitiveness or swelling and in older subjects a Roentgen picture may demonstrate its position accurately.

EXCISION OF THE ELBOW.—Excision is often advisable in adolescent or adult life, because by this procedure, in most instances, the disease may be cured in a definite time and because a movable joint may be assured.

Oschman has recently investigated the final results of the operation

performed on this class at Kocher's[1] clinic at Berne, 1872–1897. In forty of forty-five cases the operation was performed for tuberculous disease. There were no deaths referable to the operation. Of the entire number of cases, fifteen were dead, but eleven of these survived the operation for from five to twenty years. Eight of the deaths were due to tuberculosis, two to other causes and in five the cause of death was unknown. In ninety-six per cent. of the cases the local disease was cured. In sixty-eight per cent. of the cases the patients were able to use the limb at hard labor and in the others it was efficient for light work. In six cases there was subluxation or luxation, in five the joint was not firm. In fifty-nine per cent. the motions were practically normal. In eleven per cent. the joint was anchylosed. The Kocher method of exploring and excising the joint which was employed in the majority of these cases has the advantage of sparing the muscular attachments and affording an opportunity for inspection of the interior.

The incision begins upon the outer aspect of the humerus, from three to six cm. above the line of the joint and is carried directly downward over the head of the radius, passing in the interval between the extensor muscles of the arm in front and the anconeus behind. It is then carried inward and downward across the back of the forearm to a point from four to six cm. below the tip of the olecranon, then upward for two cm. on the inner side of the ulna. Thus the muscular insertions are spared. The olecranon process is then divided and turned upward and the joint is exposed. If a complete excision is to be performed the olecranon is separated from its muscular attachments and the periosteum if possible. The part must be supported until the repair is complete, and in the after-treatment lateral support by means of a light jointed brace will add to the comfort of the patient and prevent distortion.

Tuberculous Disease of the Wrist Joint.

Disease of the wrist joint is very uncommon in childhood. In a total of 3,105 cases of tuberculous disease treated in the Out-patient Department of the Hospital for Ruptured and Crippled during the past five years, 98 were of the upper extremity and in but four of these was the wrist joint involved. Of 43 cases in which the joint was resected by Ollier, the youngest patient was thirteen years of age.

Of 990 cases of disease of the joints in childhood, reported by Karewski, the wrist was involved in 31.[2]

Disease of the wrist in older subjects is less infrequent, although at all ages it is rare as compared with disease in other joints. Tuberculous disease of the metacarpus and phalanges (spina ventosa), is, however far more common.

[1] Archiv f. Klin. Chir., Bd. 60, H. 2, 1900.
[2] Chir. Krank. des Kindersalters, Berlin, 1894.

AGE AT INCIPIENCY OF DISEASE AT THE WRIST JOINT IN 18 CONSECUTIVE CASES TREATED AT THE HOSPITAL FOR RUPTURED AND CRIPPLED.

2 years old	1	19 years old	2
6 " "	1	20 " "	2
9 " "	1	25 " "	2
12 " "	2	26 " "	2
14 " "	1	27 " "	1
16 " "	2	Total	18
17 " "	1		

Males 11, females 7; right 12, left 6.

Symptoms.—The symptoms of tuberculous disease of the wrist are as in other situations **pain, local swelling and sensitiveness, limitation of motion,** caused by muscular spasm and **atrophy.** In advanced cases the hand is usually flexed somewhat upon the arm.

Treatment.—The treatment of this, as of other joints, is functional rest, with support in the attitude in which anchylosis or limitation of

FIG. 245.

Tuberculous disease of the carpus.

motion will cause the least inconvenience. A light plaster bandage extending from the elbow to the tips of the fingers, applied over a flannel bandage drawn as tight as the comfort of the patient will permit, is a satisfactory support; or a leather splint or other form of appliance may be used. The hand should be held in an attitude of moderate dorsal flexion, which will permit the flexor muscles to close the fingers easily if the wrist becomes fixed by the disease. If flexion deformity is present it should be corrected by degrees, with each application of the bandage, until the desired attitude is attained. (Fig. 247.) The flannel bandage exercises a certain amount of compression upon the wrist which seems to be of benefit, and in certain instances, this compression and fixation may be still further increased by the application of adhesive plaster. When the disease of the joint is quiescent, or in the stage of recovery, the bandage or splint may be shortened to allow the patient to use the fingers.

Prognosis.—The prognosis as regards function in cases treated promptly in childhood should be good. In the adult cases, wrist-joint

disease seems to be very often complicated by disease of the lungs, thus the prognosis as to life is often bad. In this class of cases early excision is usually recommended, with amputation as a final resort.

FIG. 246.

Tuberculous disease of the left wrist joint. The irregularity and the diminished size of the carpal bones indicate the extent of the destructive process. The patient, the mother of the child (Figs. 10–11) with Pott's disease, died within a year of tuberculosis of the lungs.

Spina Ventosa.

Central disease of the long bones of the foot and hand is the most common form of tuberculous osteomyelitis. The marrow is the seat of the disease and caseous degeneration is common. While the cortical substance is destroyed from within it is often replaced in part by a formation of periosteal bone from without, which in turn may be destroyed by the advancing disease. In the early cases the affected bone is enlarged, spindle-shaped, and is somewhat sensitive to pressure. At this stage repair may take place with but little ultimate change from the normal, but in many instances the bone is perforated and in part destroyed, the neighboring joint is involved and the finger becomes stunted and distorted.

In 159 cases tabulated by Karewski,[1] the metacarpal bones were diseased in 65 instances—the phalanges in 57—the metatarsal bones in 29—the phalanges of the toes in 8. In a number of instances sev-

[1] Chir. Krank. des Kindersalters, Berlin, 1894.

eral of the bones and larger joints were involved (159 cases in 135 patients).

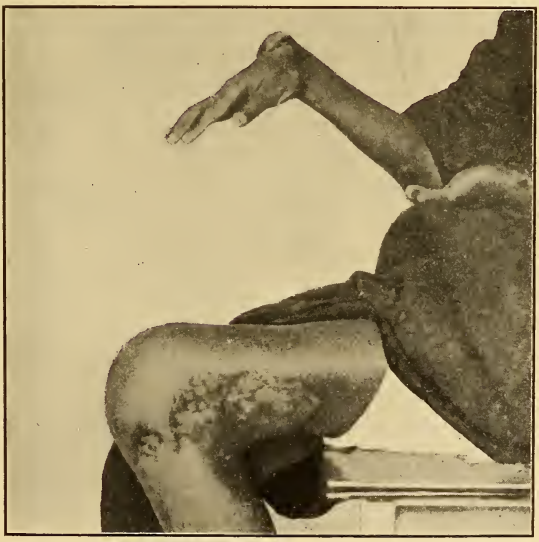
The disease is more common in the early years of life, 84 of the 135 patients being four years of age or less, 38 of these being less than two.

FIG. 247.

Treatment of tuberculosis of the wrist joint by plaster of Paris, showing the proper attitude.

Spina ventosa of the phalanges may be treated by rest and compression, and both splinting and compression may be exercised by adhesive-plaster strapping. If the joint is involved, amputation of the finger

FIG. 248.



Tuberculous disease of the wrist and knee joints showing the characteristic deformities in neglected cases of a severe type.

may be indicated because of the distortion and loss of growth that may be expected. Tuberculous disease, limited to a single bone of the carpus, or metacarpus, may be treated by operative removal of the disease.

Periarthritis of the Shoulder.

Under the title of scapulo-humeral periarthritis, Duplay[1] in 1872 described a painful affection of the shoulder induced by traumatism, dependent upon an inflammation of the bursa lying between the deltoid and the supra- and infra-spinatus muscles and the coraco-acromial ligament. But under this title are now included a number of affections that cause similar symptoms in which it would appear that the interior of the joint is not involved.

Symptoms.—In a typical case of so-called periarthritis, the patient complains of a dull pain about the joint and sensitiveness to pressure just below the acromion process or over the bicipital groove. The pain is increased by motion, particularly by abduction or by rotation of the arm. In mild cases, only extensive motion causes pain, but in most instances there is a constant sensation of discomfort which is increased to acute pain by sudden movements or jars. The part becomes sensitive to pressure so that the patient avoids lying on the shoulder at night. In certain instances the pain may radiate down the arm and there may be weakness and numbness of the fingers. Gradually the passive movements of the joint are diminished in range, and atrophy of the shoulder muscles appears.

These symptoms usually pass as rheumatism, but there is no fever, no involvement of other joints, no swelling, and, as a rule, no general sensitiveness to pressure, as is usual when the synovial membrane of the joint is affected. In certain instances these symptoms follow injury, or exposure to cold or they appear without apparent cause. In one class of cases the symptoms may be due to an inflammation of the subdeltoid bursa, as in the cases originally described by Duplay; in others to a TENO-SYNOVITIS of the biceps tendon, that may extend to the surrounding parts. This is suggested by local sensitiveness at the bicipital groove, and by the creaking sensation at this point when the muscle is in use. Or the symptoms may be due to neuritis affecting the circumflex nerves, as suggested by Amidon.[2] It is probable also that the nerves in the neighborhood of the joint may be secondarily implicated in an inflammation of bursæ, or directly injured by the original traumatism, if such preceded the symptoms. It is also possible that the bursitis may have been a sequel of gonorrhœa or of other infectious disease.

Treatment.—During the acute and painful stage the part should be kept at rest. Cautery may be applied and the joint should be enclosed in adhesive plaster strapping, and if the weight of the limb causes discomfort, it should be supported. In certain instances tension on the sensitive part may be relaxed by supporting the arm in an attitude of abduction. When the acute symptoms have subsided passive movements, massage and static electricity are of service. Voluntary exercises should be employed when they no longer aggravate the symptoms.

[1] Archiv Générale de Méd., Paris, 1872.
[2] Am. Medico-Surg. Bull., March 21, 1896.

In the cases of long standing in which motion is very much restricted, apparently by adhesions without the joint, passive movements under anæsthesia may be of benefit. In such cases it may be well to support the limb for a time in the abducted attitude to prevent the formation of the adhesions. Afterwards, passive motion, massage and exercises may be employed. If these cases are treated carefully in the early stage, recovery is usually rapid, but if neglected the symptoms may persist indefinitely.

Chronic Bursitis.

Chronic bursitis at the shoulder joint is comparatively infrequent. The bursæ most often involved are the coracoid, the sub-scapular and the deltoid. Of these the last is the most often involved. Sixteen cases have been reported by Blauvelt,[1] and three others by Ehrhardt.[2] The enlarged bursa forms a fluctuating swelling most evident on the anterior and outer aspect of the shoulder, the symptoms being discomfort, weakness and limitation of motion of the arm. The disease is usually tuberculous in character and it should be treated by incision or by complete removal of the sac, if possible.

Sprain of the Wrist.

This is a very common accident. The most effective treatment is the adhesive-plaster strapping applied about the metacarpus, wrist and lower half of the arm. If the pain on motion is severe, sufficient plaster is applied to splint the part and to limit movement to the point of comfort. If the injury is of a slighter grade the compression and support of a single layer of plaster is usually sufficient. This dressing prevents injury and yet it allows a certain degree of functional use which is the most effective means of restoring a joint to its normal condition, by hastening the absorption of the effused material within and without the joint.

Chronic Sprain.—Persistent weakness and stiffness may follow treatment of a sprain by splints, or when for any reason disuse of function has been long continued. In many instances, however, the sprain was in reality a fracture or displacement. All chronic sprains, therefore, should be examined by means of the X-ray in order that the presence or absence of more extensive injury may be determined.

The treatment is similar to that of the acute sprain, protection from injury, and functional use to the extent of which the part is capable. With this, massage, hot air and electricity or other form of local stimulation may be employed with advantage. The same treatment is indicated when the joint is stiff and painful as the result of rheumatism or other inflammation, provided the stage of recovery has been reached.

[1] Beiträge zur Klin. Chir., Bd. 22.
[2] Archiv f. Klin. Chir., Bd. 60, 1900.

Acute Teno-Synovitis.

Teno-synovitis is common at the wrist joint. It is usually induced by strain or over-use of a muscle or set of muscles. Movements of the muscles that are involved cause discomfort and there is usually local sensitiveness and a creaking sensation on palpation over the affected tendon sheath. The adhesive-plaster strapping, so applied as to exert compression and to prevent the motion that causes discomfort, is the most effective treatment.

Chronic teno-synovitis, causing progressive enlargement of a tendon sheath with accompanying symptoms of weakness and discomfort, is usually tuberculous in character. In such cases the diseased part should be promptly removed.

CHAPTER XIII.

CONGENITAL AND ACQUIRED AFFECTIONS LEADING TO GENERAL DISTORTIONS.

Rhachitis.

Synonym.—Rickets.

Rhachitis is a constitutional disease of infancy caused by defective nutrition, of which the most marked effect is distortion of the bones.

Etiology.—The predisposing cause is constitutional weakness. This may be inherited, or it may be the direct effect of illness, but most often it is the result of improper hygienic surroundings, particularly lack of sunlight, damp rooms, over-crowding and defective ventilation. The direct cause of the disease is improper nourishment. In most instances this is due to the substitution of artificial food for the mother's milk, in others to improper diet after the infant is weaned; in rare cases it may be the result of prolonged lactation, or it may be caused by the defective quality of the mother's milk. The disease therefore begins usually between the ages of six and eighteen months, although it is by no means confined to these limits. In most instances improper surroundings and improper nourishment are combined in the causation of the disease; thus rhachitis is relatively common in large cities. At the Hospital for Ruptured and Crippled the most extreme cases are observed among the Italian and the colored children. The former are usually nursed but are improperly fed after weaning, while the latter, if nursed at all, are usually allowed a mixed diet even during the early months of life.

Pathology.—The manifestations of a disease dependent upon impaired nutrition are of course general in character. In rhachitis there is a mild degree of anæmia, and a general weakness and relaxation of the voluntary and involuntary muscles. As a result the circulation is impaired and the power of assimilation is diminished, thus congestion and enlargement of the internal organs, intestinal catarrh, bronchitis and the like, are common accompaniments of the disease. The most marked and characteristic changes are found in the bones; these consist in a diminution of the earthy substances and in overgrowth of osteoid tissue.

"The essential features of the morbid process are, first, an exaggeration of the processes immediately preparatory to the development of true bone; secondly, an imperfect conversion of this preparatory tissue into true bone; and thirdly, a great irregularity of the whole process." (Erichsen.)

On section of a rhachitic bone it will be noted that the periosteum is increased in thickness, and is more or less adherent to the underlying softened and spongy tissue. The medullary canal is enlarged and its contents are abnormally vascular. The epiphyseal cartilage, normally a thin bluish line, is much increased in thickness. It appears to be swollen and infiltrated, and it has lost its former translucency. Microscopical examination at this point, where growth is most active, shows marked irregularity in size and shape of the columns of cartilage cells; the zone of calcification is lacking or is ill-defined, and masses of cartilage cells are found unchanged in what should be the area of true bone. The same irregularity of line and shape is observed in the medullary spaces of the newly formed osteoid tissue.

FIG. 249.

General rhachitic deformities, showing distortions of the arms.

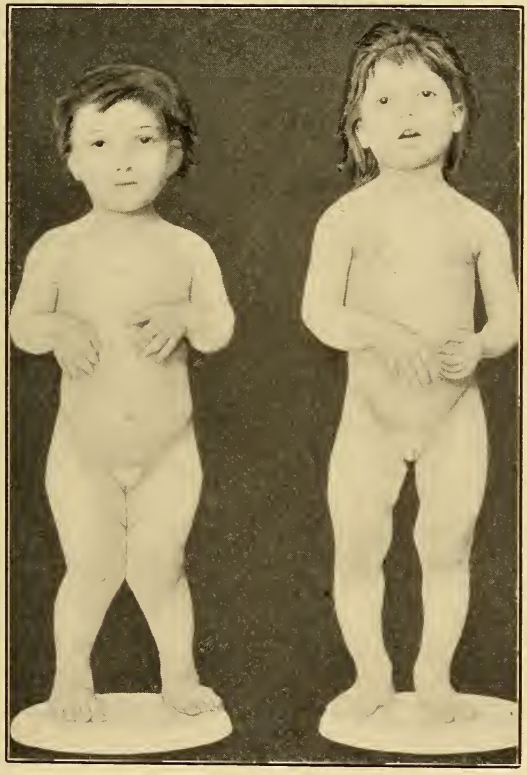
As a direct result of the changes that have been described, the epiphyseal junctions are enlarged and the shafts of the bones are thickened by the formation of osteoid tissue beneath the periosteum. The indirect effects of the disease, and of the weakness that it causes, are deformities, the nature of which will be indicated under the heading of symptoms. The stage of weakness is followed by that of repair, which sometimes goes on with great rapidity; the softened bones become abnormally hard, "eburnated," and premature solidification at the epiphyseal junctions may be one of the more remote results of the disease, that accounts in part for the dwarfing of the stature, observed as one of the final results of severe rhachitis.

Symptoms.—As the disease is the effect of imperfect assimilation its more pronounced symptoms are preceded by those of indigestion, such as flatulence, constipation and the like. Profuse perspiration, especially about the head, and restlessness at night are common symptoms. Teething is often delayed or is irregular. The infant is slow in its movements and makes little effort to stand or to walk at the usual time, and if the disease is active, the affected parts may be sensitive to pressure.

Deformities.—The deformities are in part due to the direct effect of

the disease. One of the earliest and most constant evidences of rhachitis is the enlargement about the epiphyses, an enlargement caused in part by the direct hypertrophy, and in part by pressure upon the softened tissues. The enlargements at the junctions of the ribs and the costal cartilages, the "RHACHITIC ROSARY," and at the wrists and ankles, "DOUBLE JOINTS," are almost invariably present in well-marked cases. The more general distortions are in part the effect of atmospheric pres-

FIG. 250.



Chondrodystrophia of slight degree contrasted with ordinary rhachitis, in sisters. 1. Chondrodystrophia. Broad, short, very flexible hands, trunk disproportionately long—knock knees. Age 5½ years, height 30½ inches; normal height 40 inches. 2. Rhachitis, bow legs, age 4 years; height 32½ inches; normal height 36 inches.

sure, in part the effect of the force of gravity and habitual postures, and in some instances muscular action or injury may deform the softened bones. These deformities differ greatly according to the time of onset of the disease, and with its duration and severity. The head may be long and oblong in shape, or rectangular, "CAPUT QUADRATUM," and it sometimes presents prominences in the frontal and parietal regions due to thickening of the bones, and on the posterior aspect depressed and softened areas, "CRANIOTABES." The fontanelles

are abnormally large and they may remain open long after the usual time of closure.

The thorax is compressed from side to side, the compression being most marked in the middle region where the ribs have the longest cartilages and the least direct support. As secondary results, the back of the chest is flattened and the sternum is thrust forward forming the PIGEON BREAST. The lower ribs are everted to accommodate the distended abdomen, "POT BELLY." In well-marked cases the rhachitic chest presents two distinct grooves, one transverse in the axillary line, "HARRISON'S GROOVE," and the other passing upward by the side of the rhachitic rosary. These deformities are in great degree caused by atmospheric pressure, but they are increased if the child assumes the sitting posture habitually. In this attitude the body is inclined forward, the clavicles are distorted and the spine is bent into a more or less rigid posterior curve, most marked in the lower dorsal and lumbar regions, the "RHACHITIC SPINE." Less often there may be a lateral deviation or SCOLIOSIS.

The arms may be distorted by the efforts of the child to support the body in the sitting posture, or by active exertion, as in creeping. (Fig. 249.) Occasionally the deformities may be localized at the elbows, and sufficiently marked to merit the name CUBITUS VARUS or VALGUS, corresponding to genu valgum or varum; or the principal distortion may be a dorsal convexity of the lower extremity of the radius.

The bones of the lower extremity are often distorted, primarily by the habitual postures assumed in sitting or creeping and these deformities are usually exaggerated when the erect attitude is assumed. In some instances it would appear that the femoral necks are twisted backwards somewhat; this distortion may explain in part the limitation of inward rotation that is sometimes observed in rhachitic children. The changes in the pelvis are of special interest to the obstetrician. These are essentially an increase in the sacro-vertebral prominence, due to the forward and downward displacement of the sacrum, an abnormal expansion of the ilia, caused by pressure of the abdominal contents and, in some instances, a decrease of the lateral diameter, an effect of the pressure of the femora upon the yielding bone.

In the milder type of rhachitis in older children, who walk, the deformities are often confined to the trunk and lower extremities. In such cases, in addition to the changes in the bones, there is usually a prominent abdomen and increased lordosis, combined with slight habitual flexion of the thighs and lower legs, the "RHACHITIC ATTITUDE."

If the disease is of sudden onset and is severe and general in its manifestations, it may be accompanied by pain, by sensitiveness of the affected bones and by such weakness of the lower extremities as may simulate paralysis, RHACHITIC PSEUDO-PARALYSIS.

It is probable, however, that the cases in which the pain is extreme, "acute rhachitis," are, in reality, scurvy or scurvy and rhachitis combined, scurvy rickets so-called.

Rhachitis, as described, is the type ordinarily seen in hospital prac-

tice and its manifestations are unmistakable. In its milder form it is not particularly uncommon among the children of the well-to-do, whose hygienic surroundings are good. In such cases the most marked symptom is weakness. The child is often fat and well developed, although, as a rule, pale. The abdomen is somewhat enlarged and slight prominences at the epiphyseal junctions, particularly at the wrists, may be made out. The legs appear small in proportion to the body and the ligaments are lax, so that if the child stands the feet are flat and assume the attitude of valgus. In this class, in which the child is said to have weak ankles, knock knee is common.

The most common symptom then of mild rhachitis is the failure of the child to attempt to walk at the usual time, about sixteen months. If a child who is not ill and who has not suffered from exhausting disease does not walk at two years of age, it is probably rhachitic.

Prognosis.—The duration of the progressive stage of rhachitis depends, of course, upon the age of the patient and upon the treatment. In cases that are untreated and in which the predisposing causes continue, the period of repair may be delayed for several years or longer, as shown by the fact that the child makes little effort to stand; but, in most instances, the rhachitic child begins to walk at some time during the third year and at this time the deformities of the lower extremity, knock knee, bow leg, flat foot and the like, usually develop or become aggravated, while those of the upper extremity may become less noticeable.

The deformities of rhachitis tend to disappear or to become less marked with growth; the concavities of the distorted shafts are filled by accretions of periosteal bone, which is again absorbed from the interior as the medullary canal straightens itself. The thickened diaphyses and enlarged epiphyses become more symmetrical under the influences of rapid growth and increased functional activity, but traces of severe rhachitis always remain and many of the more noticeable and permanent distortions of the trunk and of the lower extremities are due to this cause.

The prognosis as to the outgrowth of rhachitic deformities depends upon the duration and the severity of the disease and upon the function of the deformed part. Rhachitic distortions of the arms almost always disappear. The rhachitic chest is rarely seen in the adolescent or adult. The rhachitic kyphosis is corrected or modified when the erect posture is assumed, but rhachitic scoliosis, on the other hand, usually increases with the growth. Distortions of the lower extremities may entirely disappear and in most cases they are less marked in the adult than in the child. Stunting of the growth is a constant effect of severe and prolonged rhachitis; it depends in part upon the arrest of development during the active stage of disease and in part upon the changes in the bones that cause premature consolidation at the epiphyses.

Treatment.—The treatment of rhachitis consists essentially in a reversal of the conditions under which it developed. It is therefore die-

tetic, hygienic and medicinal. Deformity, the effect of the disease, may be prevented by guarding the weakened bones from overstrain, or it may be remedied, if it be present, by manipulation or by mechanical or by operative treatment.

The more detailed treatment of rhachitis may be found in works on Pediatrics. In general, the diet in the cases developing in early infancy should be of milk, especially modified according to the need of the patient. At a later time, corresponding to the normal period of weaning, the diet should be largely animal, to the exclusion of starchy food; cream and fresh butter being especially valuable.

The patient, protected by proper woolen underclothing, should pass as much time as possible in the open air and should sleep in a well-ventilated room. Daily salt baths are recommended for older children and regular massage of the extremities, and of the abdomen, should be employed. Medicinal treatment is of secondary importance. The bowels should be regulated and digestion should be aided by proper remedies. For anæmia, which is usually present, the syrup of the iodide of iron is of value; cod-liver oil serves both as a food and medicine, when it is readily assimilated. It is unlikely that any drug has a very direct influence on the disease. Phosphorus in doses of 1/200 to 1/100 of a grain is often given and is supposed to lessen the abnormal congestion of the bones, while the deficiency of lime salts may be supplied possibly, by the administration of lime in some form, the syrup of the lactophosphate of lime being a favorite prescription.

The prevention of deformity, other than by the means already enumerated, consists in preventing habitual postures that predispose to deformity, and in daily massage and manipulative correction of beginning distortions. Young infants and those whose bones are especially vulnerable should spend much of the time in the reclining posture. The Bradford frame, or similar appliance, is especially useful in the treatment of this class of cases. The treatment of the more advanced deformities, by support or by operation, is described elsewhere.

"Late Rickets."

Late rickets is, as the name implies, an affection presenting all the characteristics of the common infantile form. This, in rare instances, appears in later childhood or even in adolescence; in some cases the affection appears to be a continuation or recrudescence of the infantile form; in others no history of a preceding affection can be obtained.[1]

By many writers the term late rickets is improperly used to explain the deformities of adolescence, genu valgum, coxa vara and the like, although none of the distinctive signs of the affection may be present. Local rickets is less objectionable as applied to the same class of cases, although pathological specimens present little evidence of actual local disease.

[1] Drewitt, Trans. Lond. Path. Soc., Vol. XXXII., 1881. Clutton, St. Thomas' Hosp. Reports, Vol. XIV., 1884.

Fœtal Rhachitis.

Synonyms.—Chondrodystrophia, Achondroplasia.

Cases that present the signs of what appears to be severe general rhachitis at birth, are not especially uncommon. The trunk is disproportionately long as compared to the stunted limbs; the head is large, the chest presents a pigeon-like distortion and the epiphyses appear to be generally enlarged. In some instances the back is curved into a rigid kyphosis or scoliosis, and restricted motion, or apparent fixation, of many of the joints may be present.

Etiology and Pathology.—These cases were formerly supposed to be instances of intra-uterine rhachitis; chondrodystrophia is not however the result of a disturbance of nutrition, it is due apparently to a congenital defect in the bones themselves or rather of the original cartilage. Rhachitis is characterized by hypertrophy of the epiphyseal cartilages and by delayed ossification. In chondrodystrophia, on the contrary, there is atrophy of the epiphyseal cartilages and abnormal rapidity of ossification. On section of a bone the shaft is seen to be thickened and stunted, the epiphyses are enlarged also and these hypertrophied and prematurely ossified segments may overhang the diminutive cartilage that intervenes.

Chondrodystrophia, or an affection resembling it, is sometimes seen (Fig. 250) in a very mild form; the appearance of the child suggests rhachitis, but the stunting of the growth is greater than is ever the result of rhachitis of corresponding severity.

Cretinism.—Cretinism may cause a similar dwarfing of the stature, and cretinism may be combined with chondrodystrophia, but in most instances the symptoms of mental deficiency that accompany cretinism, are lacking in this affection.

Treatment.—The treatment of so-called fœtal rhachitis consists in regular massage and manipulation of the distorted parts and of the anchylosed joints. This treatment may extend over several years, during which the limbs and back must be protected. Rest on the Bradford frame during the period of active treatment, is advisable. If congenital cretinism is suspected, the administration of thyroid extract would be indicated.

Prognosis.—By persistent treatment the range of motion in the stiffened joints may be regained, but the prognosis is bad. The patients present in later years the abnormally long trunk and stunted extremities that were present at birth.

Infantile Scorbutus.

Synonyms.—Scurvy, Scurvy Rickets.

Scurvy in infancy, as at other periods of life, is a constitutional disease, dependent upon impaired nutrition, caused apparently by the deprivation of proper food. The disease was originally described by Smith and Barlow as scurvy rickets, but it may, and often does, occur independently of the latter affection.

Pathology.—The pathological changes most often found in cases of the advanced type are hemorrhages beneath the mucous membranes and the periosteum. Separation of the epiphyses may occur.

Symptoms.—The disease is most often observed in bottle-fed infants from six to eighteen months of age. In some instances the patients are evidently ill-nourished, but in others they may appear to be in good condition. The early symptoms resemble rheumatism. The child shows evidences of discomfort when certain joints are moved, and as the disease progresses it may scream whenever it is turned or lifted. The painful joints are sensitive to pressure and they may be somewhat enlarged, but local heat and redness, as well as fever, are, as a rule, absent. After dentition the gums may be swollen and spongy, and hemorrhages into the skin or beneath the mucous membranes may occur. In extreme cases the swelling about a joint due to effusion of blood and accompanied, it may be, by separation of the epiphysis may be mistaken for the symptoms of infectious epiphysitis or even for sarcoma.

Treatment.—The treatment consists primarily in the regulation of the diet, particularly in the substitution of fresh milk, properly modified, for the patent food or sterilized milk that may have been employed. This should be supplemented by orange juice, or that of other fresh fruit. The change of diet usually relieves the symptoms. During the painful stage of the disease complete rest in the horizontal position on a pillow or frame, may be indicated; later, massage of the limbs and back may be of service in improving the nutrition, and remedying slight deformity.

Fragilitas Ossium.

Synonym.—Idiopathic Osteopsathyrosis.

There are many conditions that cause local or general fragility of the bones and thus an increased liability to fracture. For example, the weakness of old age, sometimes called senile rickets; the atrophy caused by disuse incidental to chronic joint disease, or the weakness that may be caused by certain diseases of the nervous system. Weakness of the bones may be general in character, as when it is the result of osteomalacia or rhachitis.

Idiopathic fragility or osteopsathyrosis is of congenital origin. The bones appear to be weak simply because of a failure in the formation of periosteal bone. In such cases, there may be distortions at birth, apparently caused by intra-uterine fractures, and in after life, fracture may follow the slightest accident or sudden motion. Blanchard[1] has reported a case in which there were seventy distinct fractures between the ages of two months and twenty-seven years. A similar case was for many years under treatment in the Hospital for Ruptured and Crippled. For a part of the time the body and trunk were inclosed in a plaster of Paris casing, to prevent the fractures that followed even

[1] Trans. Am. Orth. Ass'n, Vol. VI.

ordinary movements. At the age of fourteen the strength of the bones had increased sufficiently to enable the patient to walk about with the support of braces, but he was, in stature, about the size of a child of seven years.

Fractures in this class of cases are attended with but little pain. They unite slowly with but a small callus. It is practically impossible to prevent a certain amount of deformity. With advancing years the liability to fracture may diminish, but as a rule the patient is disabled.

The treatment is protective. Massage is of service in improving nutrition. Medication is of little avail.[1]

Fig. 251.

Osteomalacia.

Osteomalacia.

Synonym.—Mollitis Ossium.

Osteomalacia is a disease of an inflammatory nature, characterized by an absorption of the earthy substances (decalcification) of the bones and by deformity. The disease is one of adult life. It is far more common among females than males, and pregnancy, in about half of the cases that have been reported, seemed to be the exciting cause. The disease usually begins insidiously. The symptoms are pain on motion referred to the pelvis and to the thighs. This is supposed to be of rheumatic origin until the character of the affection is made evident by the weakness of the limbs and by the deformities. These deformities are of greater interest to the obstetrician than to the surgeon, for when the affection complicates pregnancy, the distortion of the pelvis may be so great as to prevent normal delivery.

Osteomalacia in Childhood.—Three cases of osteomalacia in childhood have been reported by Siegert,[2] and one case has come under my observation. The patient, one of twelve living children of healthy parents, was nursed by his mother for the usual period, and until the

[1] Porak, Bul. et Mém. de la Soc. Obst. et Gyn. de Paris, 1890. Salvetti, Beitr. zur Path. Anat. und Allg. Path., Bd. XVI., 1894.

[2] Münch. med. Wochens., Nov. 1, 1898.

age of four years he appeared to be perfectly healthy. At this time without known cause general weakness of the lower limbs became apparent, and at the same time deformities of the lower extremities developed. At the age of six years he was unable to stand. At the present time the condition of the patient, now nine years of age, is shown in the preceding illustration. There is no evidence of rhachitis or of paralysis. The patient has never suffered from pain or discomfort. The lower extremities are somewhat atrophied from disuse, the bones are abnormally flexible and are distorted to a moderate degree. The epiphyses are not enlarged. (Fig. 251.)

Treatment.—As the etiology of the affection is unknown, treatment is symptomatic and palliative.

Osteitis Deformans.

This disease was first described by Paget[1] in 1877. It is a chronic inflammatory affection of the bones, characterized by hypertrophy and softening. "The bones enlarge, soften, and those bearing weight become unnaturally curved and misshapen."

Section of an affected bone shows it to be markedly increased in size, and somewhat in length, by a combination of rarefying and formative osteitis. The inner layers become porous, and at the same time new bone is deposited beneath the periosteum.

The disease appears to be confined to adult life, and is equally divided between the sexes. Although but a single bone may be affected, as a rule the lesion is symmetrical and more general in its area, the bones of the lower extremity, the skull and the spine being more often involved. Thus, the head progressively increases in size, and the legs become bowed. If the spine is affected it bends forward forming a long, more or less rigid, kyphosis.

Aside from the deformities and the characteristic enlargement of the bones, the symptoms are not marked. At times complaint is made of pain usually supposed to be rheumatic until the characteristic changes in the bones appear. The disease is extremely chronic in its course, and as a rule the general health is not seriously affected. In several instances sarcoma of bone finally caused death many years after the onset of the disease. Its etiology is unknown, its treatment is palliative.

Secondary Hypertrophic Osteo-Arthropathy.[2]

Osteo-arthropathy is an inflammatory disease of the bone characterized by hypertrophy, clubbing of the fingers and effusion into certain of the joints. The hypertrophy is caused by a deposition of layers of bone beneath the periosteum of the metacarpal and metatarsal bones, the phalanges and the distal extremities of the adjoining bones of the

[1] Med. Chir. Trans., Vol. 40 and Vol. 65, 1882.

[2] Marie, Revue Medical, Paris, 1890, X., p. 1. Bamburger, Wiener klin. Woch., N. 11, 1889. Deutsche Chir., L. 28, 1899.

arms and legs. Less often the area of the disease is more extensive, involving the femora, the humeri and the spine even.

Osteo-arthropathy is usually a complication of preëxisting chronic disease, most often of the lungs. The patient first notices clubbing of the terminal phalanges and hypertrophy of the finger nails, later an increasing enlargement of the wrists and ankles and of the hands and feet, accompanied by discomfort, sensitiveness to pressure and often by effusion into the neighboring joints, symptoms that would be classed as rheumatic were it not for the evident hypertrophy.

The clubbing of the fingers is due, in part at least, to impairment of the circulation and the connection of the disease of the bones with that of the lungs has suggested the theory that it is caused by the absorption of toxines and that its etiology is similar to the amyloid hypertrophy of the internal organs that sometimes follows chronic disease of bones and joints attended by suppuration.

The treatment is symptomatic and as the affection is almost always secondary to a graver disease, but little is known of its outcome. It is certain, however, that the secondary osteo-arthropathic symptoms become less marked or may even disappear as the patient recovers from the original disease of the lungs or other organs. The affection is very uncommon in childhood, but one typical case having been recorded.[1]

Acromegalia.

This affection is also characterized by progressive enlargement of the hands and feet, but it differs from osteo-arthropathy in that all the tissues are involved in the hypertrophy. The hypertrophy of the bone is limited to the epiphyseal extremities and is slight compared with that of the soft parts. The face is often involved, the tissues of the nose, lips and ears being enlarged and thickened, together with the underlying bones, so that the expression is very markedly changed.

Acromegalia is common among those of gigantic stature. The local hypertrophy and the giganticism both being due, it is supposed, to disease of the pituitary gland.

Diagnosis.—The three affections that have been described, osteitis deformans, osteo-arthropathy and acromegalia, are rare diseases and they are of little practical interest to the surgeon other than from the standpoint of diagnosis. This might be somewhat difficult if the pathological process were confined to a single bone or limb, as is sometimes the case in osteitis deformans.

The essential characteristics of the three diseases may be summarized as follows: In osteitis deformans the entire bone is increased in size and length, and because of the coincident weakening of its structure, it becomes distorted; the skull is often involved but the hands and feet are not often affected. It is a disease of middle or later life and there are, as a rule, no symptoms other than those due to the local changes in the bones.

[1] Whitman, Pediatrics, February 15, 1899.

In osteo-arthropathy the process is an hypertrophy, but of a slight degree, caused by deposition of periosteal bone especially about the distal extremities of the shafts of the bones adjoining the hands and feet. It is not often accompanied by the weakness or the deformity that is characteristic of the preceding affection; the skull is not usually involved, but the long bones of the hands and feet are thickened so that these members are markedly increased in size. There is often coincident discomfort and swelling of the neighboring joints. As a rule the local affection of the bones is secondary to chronic disease of the lungs.

In acromegalia the marked changes are hypertrophic enlargements of the hands and feet in which all the tissues are involved; the hypertrophy of the bones is most marked about the epiphyses, the diaphyses remaining unaffected; thus it differs from the preceding disease, in which similar enlargement of the extremities occurs. The head is often involved, but the hypertrophy is of all the structures of the face, not of the skull as in osteitis deformans.

The disease appears to be confined to early adult life and it is often preceded or accompanied by symptoms of a general nature, headache, mental impairment and the like.

The changes in the bones characterizing the affections may be easily demonstrated by means of the Roentgen pictures.

CHAPTER XIV.

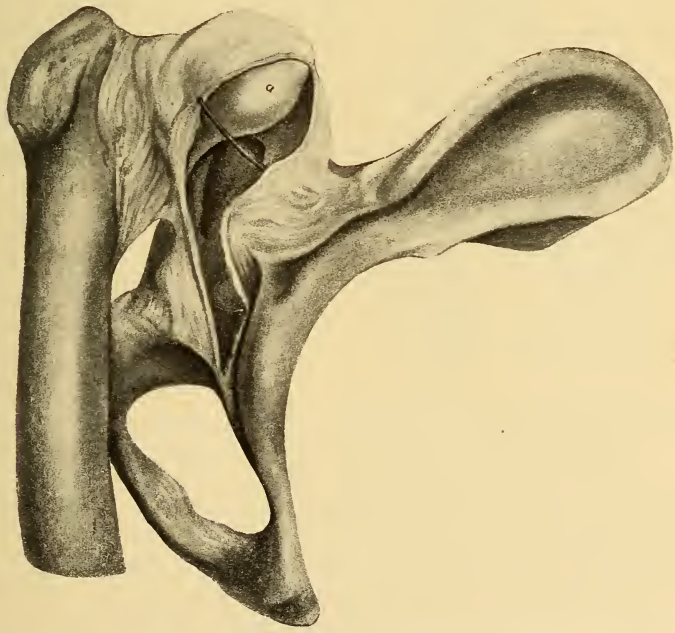
CONGENITAL DISLOCATION OF THE HIP AND COXA VARA.

Congenital Dislocation at the Hip Joint.

Of all the congenital dislocations or, perhaps, more properly misplacements, that of the hip joint is by far the most common and the most important.

Statistics.—Congenital dislocation of the hip is much more common in females than in males. In 671 cases collected from different sources

Fig. 252.



Congenital dislocation of the hip showing the elongated capsule and the right angled relation of the neck to the shaft of the femur. (William Adams.)

by Lorenz, 589 (87.8 per cent.) were in females and 82 (12.2 per cent.) in males. Of 1,039 cases seen at the Polyclinic in Milan, 867 (83.4 per cent.) were in females, 172 (16.6 per cent.) in males.[1] In 500 cases from the records of the Hospital for Ruptured and Crippled, in-

[1] Bernacchi, Zeits. Orth. Chir., Vol. II., p. 275.

vestigated for me by Dr. C. P. Flint, 413 (82.6 per cent.) were in females and 87 (17.4 per cent.) in males.

The dislocation is more often unilateral than bilateral. In Lorenz' series of 671 cases, 421 (64.4 per cent.) were single; 225 of the right, 196 of the left side. In 245 cases (36.6 per cent.) the displacement was bilateral.

STATISTICS OF 500 CASES OF CONGENITAL DISLOCATION OF HIP, RECORDED AT THE HOSPITAL FOR RUPTURED AND CRIPPLED.

Males	87	17.40 per cent.
Females	413	82.60 "
Total	500	100.00 "
Right hip	135	27.66 per cent.
Left hip	218	44.47 "
Both	136	27.87 "
	489	100.00 "
Not specified	11	
	500	

MALES.

Right hip	25	30.48 per cent.
Left hip	32	39.04 "
Both	25	30.48 "
	82	100.00 "
Not specified	5	
	87	

FEMALES.

Right hip	110	27.04 per cent.
Left hip	186	55.69 "
Both	111	27.27 "
	407	100.00 "
Not specified	6	
	413	

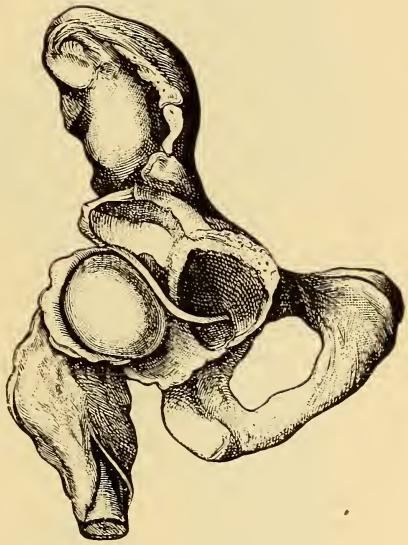
The dislocation at the time when the patients are brought for treatment is almost always posterior, upon the dorsum of the ilium; in other instances it is anterior, so that the head of the bone may be felt beneath the anterior superior spine. It is possible however that the primary displacement may be in certain instances directly upward.

Pathology.—The pathological anatomy of the dislocation was first clearly demonstrated by Dupuytren in 1826, and since 1890, when the open operation was first performed, the exact relation and the appearances of the different components of the joint have been described in detail by Hoffa, Lorenz and other operators.

The condition of the joint varies with the age of the patient and the strain and friction to which the displaced parts have been subjected. In early infancy it may be assumed that the head of the bone lies in close proximity to what is, in some instances, a practically normal acetabulum; in others to one that is somewhat rudimentary, often

shallow and small, sometimes of an oval but usually of a somewhat triangular shape. The ACETABULUM is covered with normal hyaline cartilage, the ligamentum teres is present and the capsule is of nearly normal structure. At a later time when the joint is exposed at operation at the age of five or more years, the rudimentary acetabulum may be partly filled with cartilage, fat and fibrous tissue, so that it may be almost on a level with the surrounding bone. As a rule, however, a well-marked ridge indicating its posterior and upper margin can be made out and in many instances it appears to be of fair size and depth. The CAPSULE is elongated to accommodate the upward dislocation of the femur. It is hypertrophied, especially where it covers the upper part of the head of the bone, and it is often drawn into a shape like an hour glass; the upper part contains the head of the bone, the anterior wall is drawn tightly across the acetabulum, forming at its upper border a narrow slit-like communication, through which the ligamentum teres passes, if it be present. (Fig. 252.) The interior of the capsule is in part lined with synovial membrane, and it often contains more synovial fluid than is found in the normal joint.

FIG. 253.



Congenital dislocation of the hip, showing the original and the acquired acetabula. (LORENZ.)

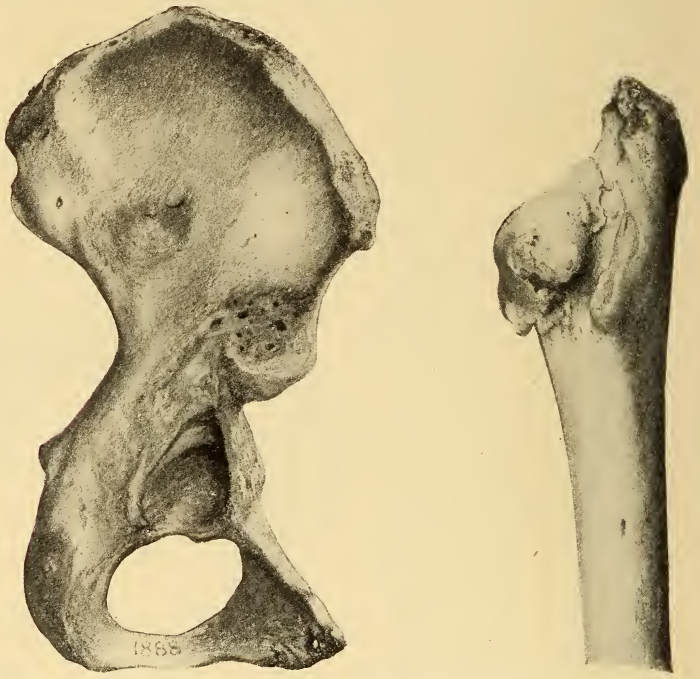
The LIGAMENTUM TERES, although probably present at birth in a large proportion of the cases, becomes attenuated and ribbon-like with the increasing elongation of the capsule, and after the age of five years or at the time when the open operation is performed, it is usually absent. According to Lorenz in 52 cases between two and a-half and five years it was present in 17; in 48 cases beyond the age of five years it was present in but 4. In rare instances it may be hypertrophied. In my own experience the ligament is present in a very much larger proportion of the cases, although it is often so rudimentary that it might easily be overlooked.

A shallow SECONDARY ACETABULUM, formed in part by the direct pressure of the head of the bone through the adherent capsule, and in part the result of irritation of the periosteum, is usually found upon the ilium (Fig. 253), but it is not often of sufficient depth to assure a secure support for the head of the femur; thus its upper margin gradually recedes or two distinct depressions may be formed one above the other. The upper extremity of the FEMUR is usually somewhat atrophied. The neck is often shorter than normal, and its angle may be lessened,

and in many instances its forward inclination is increased. The head of the bone may be nearly normal although usually it is somewhat flattened on its inner and under surface, or it may be somewhat conical in shape, or again compressed from side to side to an almond shape or otherwise distorted. The abnormalities, in part congenital, become more marked with age, and in adult specimens the head and neck of the femur may be so atrophied and worn away that it has little semblance of normal contour. (Fig. 254.)

There are also secondary changes in the bones of the **pelvis.** In unilateral dislocation the pelvis is usually somewhat atrophied on the

FIG. 254.



Congenital dislocation of the hip showing the depressions in the ilium and the final effect of pressure and friction upon the femur. (ADAMS.)

affected side, and a lateral inclination of the spine may be present. The final changes in the pelvis caused by the bilateral dislocation, are more important; its inclination is increased, the lumbar lordosis is exaggerated, the sacrum is forced forward and downward so that the antero-posterior diameter is lessened; the tuberosities of the ischia are everted and the transverse diameter of the pelvic outlet is increased.

The long **muscles** of the thigh are shortened, while those attached about the trochanter are changed in direction and are usually lengthened. There is also a slight general muscular atrophy that is particularly marked in the gluteal group.

The changes that have been described are in great degree secondary to the displacement. They are in part congenital, in part accommodative and in part due to the influences of attrition and injury, to which the abnormal mobility predisposes; thus, as a rule, they become more marked with increasing age, and in some of the adult specimens but little resemblance to the normal parts remains.

As a rule, congenital dislocation of the hip is not accompanied by defective development or deformity elsewhere: although cases

Fig. 255.

Unilateral dislocation showing the inclination of the body toward the shorter leg.

Fig. 256.

The same patient before operation, showing the abnormal lordosis and rotation of the pelvis. (See Figs. 270, 271.)

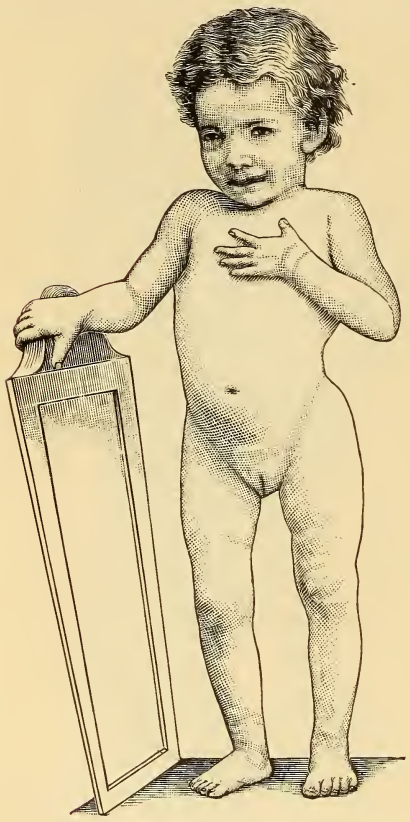
are sometimes seen in which a general laxity of ligaments is present or in which the dislocation may be one of a series of deformities and malformations.

Etiology.—Nothing positive is known of the etiology of the dislocation. In a small proportion of the unilateral cases it may be due to violence at birth, but the fact that nearly 85 per cent. of the patients are females makes it evident that the primary cause can be neither injury nor disease.

Hereditary influence can be established in a few instances. The writer has examined three female children in a family of nine, in each of whom there was dislocation of the left hip, the order being the third, eighth and ninth child. Also twins in another family, one having single and the other double dislocation. And in two instances, congenital displacement was present in the mothers of patients.

Of the various theories that have been advanced to account for the condition, the most reasonable seems to be defective development. This defective development may affect the entire acetabulum or it may involve only its posterior margin, or the cause of the displacement may be an abnormal laxity of the capsule that predisposes to displacement when the thighs are flexed and adducted.

FIG. 257.



Congenital dislocation of both hips, illustrating the separation of the thighs, the abnormal breadth of the pelvic region, and the prominent trochanters.

Heusner,[1] from an examination of 26 fœtuses concluded that the greater liability of females to the dislocation is explained by the disproportionate laxity of the capsule as compared with males.

It is probable that the dislocation, in some cases at least, is at birth a subluxation only, that becomes complete through muscular action and the use of the limb in standing and walking.

Symptoms. — The displacement does not as a rule attract attention until the child begins to walk; although in some cases the mother may have noticed a peculiar breadth of pelvis, or a "lump" on the buttock, or a "snapping" about the hip joint, or a peculiar attitude of the limb before this time.

UNILATERAL DISLOCATION.—If the displacement is of one side, a **limp** is immediately apparent, which becomes more noticeable as the child grows older. The limp is peculiar and its character is explained by its cause; for the leg is not only shorter than its fellow, but owing to the elasticity of the capsule, it becomes still shorter when the weight falls upon it, so that in walking there is a peculiar lunge of the body toward the short leg, that has been likened to the motion in walking

[1] Zeits. für Orth. Chir., Bd. V., H. 2, 3.

down stairs. The head of the bone is displaced upward and backward, and in compensation the pelvis is tilted toward the short leg and its inclination is increased; it is thus twisted downward and forward so that the anterior superior spine lies at a lower level, and in advance of that of the opposite side. (Figs. 255, 256.)

At an early age the **shortening** of the leg, due to the elevation of the trochanter, is from one-half to three-quarters of an inch. In adolescence, the elevation is from one and one-half to two inches, and in adult life it may be considerably more.

The effect of the displacement is also shown by a flattening of the **buttock**, and usually the elevated and prominent **trochanter** may be seen as an abnormal lateral projection, on a level with the anterior superior spine which is, as has been stated, somewhat tilted downward.

In childhood, **motion** in the false joint is more free than normal, and the abnormal mobility can be demonstrated by alternate traction and upward pressure on the limb, but as the femur becomes larger and the upward displacement increases, the mobility is restricted; the range of abduction is much diminished, and not infrequently the limb becomes permanently adducted and flexed, thus adding the apparent shortening of adduction to that caused by the dislocation. (Fig. 259.)

Fig. 258.

Bilateral congenital dislocation of the hip, showing the exaggerated lordosis.

Bilateral Dislocation. — When the location is bilateral the shortening is, as a rule, equal or nearly so, and as both femora are displaced backward the pelvis is tilted forward; thus in compensation "the hollow" of the back is increased, the abdomen protrudes, the

buttocks are flattened, the pelvis appears to be abnormally wide and the thighs are separated by a considerable interval. (Figs. 257, 258.) The limp characteristic of the single displacement is replaced by an exaggerated **waddle**, a "sailor gait."

General Symptoms.—In early childhood there are no especial symptoms other than the limp or the waddle but as the child becomes more active it usually complains of **discomfort** after exertion. It is easily fatigued and at times it may suffer actual pain. These symptoms are of course more marked in the double than in the single displacement, because in the latter case the normal leg is capable of bearing more than its share of the strain. The symptoms often increase during adolescence but they may become less troublesome in adult life, when the head of the bone may have found a permanent resting place on the pelvis; a security assured, however, by a corresponding limitation of the range of motion. But the shortening and the secondary effects of the displacement of course remain, so that the individual

Fig. 259.

Congenital dislocation in an adolescent, illustrating the flexion-contraction in a well-marked case.

is, as compared with the normal standard, more or less disabled and deformed.

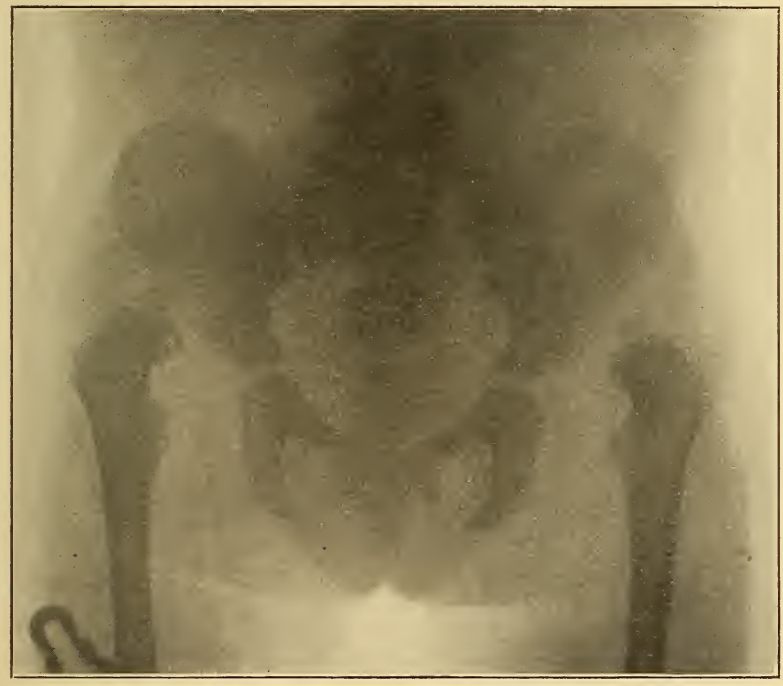
The great majority of the patients are females and because of the less laborious occupations and the distinctive dress, the disability and its effects are less serious than if the displacement were more equally divided between the sexes.

Anterior Dislocation.—The symptoms of the anterior dislocation in which the head of the bone lies beneath the anterior superior spine, are much less marked because the relation of the pelvis to the femur is nearly normal, so that secondary deformity is slight. The shortening is less and the resistance of the tissues attached to the anterior superior spine is sufficient to assure a more secure support than in the ordinary form.

Diagnosis.—The diagnosis offers no difficulty. The history of the limp or waddle noticed when the child began to walk and yet unaccompanied by pain or preceded by injury or disease, is in itself suffi-

ciently distinctive. If the displacement is of one side, measurement demonstrates the shortening as compared with the other limb, a shortening that is explained by the prominence, and the elevation of the trochanter above Nélaton's line. Traction and upward pressure on the leg will demonstrate the abnormal mobility of the displaced head; and finally if the thigh be flexed and adducted to its extreme limit, the neck and head of the femur can be easily distinguished moving under the gluteal muscles when the leg is rotated. Thus it may be differentiated from depression of the neck of the femur (COXA VARA), in which, although the trochanter is elevated, the neck and head of the bone can-

FIG. 260.



Bilateral congenital dislocation of the hip.

not be felt, and in which the abnormal mobility, characteristic of the dislocation, is absent. Again, coxa vara is almost never a congenital affection, therefore the history itself would practically exclude it.

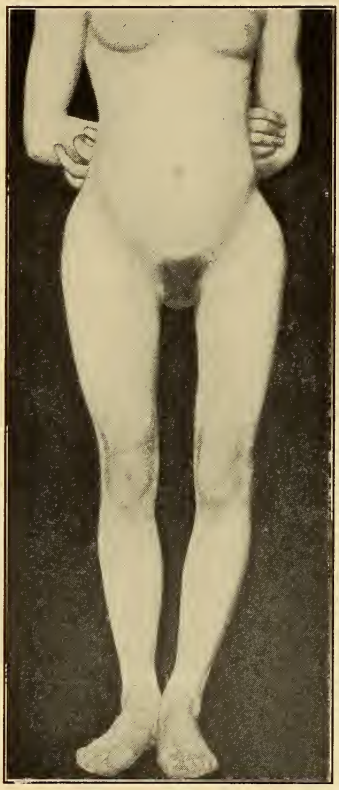
Upward displacement of the femur not infrequently follows INFECTIOUS EPIPHYSITIS of infancy or early childhood. In such cases a part of the upper extremity of the bone is usually destroyed so that the head cannot be distinguished on palpation. Although the other physical signs are similar to those of the congenital displacement, the scars about the joint show the evidence of former disease, and the history is almost always available for diagnosis, so that as a rule, such disabilities, as

well as traumatic dislocations or other results of injury or disease, are readily excluded. (Fig. 217.)

The double congenital dislocation presents the same local signs as the single form; it is even more easily recognized by the peculiar appearance and distinctive gait of the patient.

The waddling gait may be simulated by that of extreme BOW LEGS, but the hip joints are, in this deformity, normal in appearance and function. The waddle of LUMBAR POTT'S DISEASE is also somewhat similar, but this is an acquired painful disease of the spine, in which the hip joints are normal in appearance and usually so in function.

FIG. 261.



Bilateral dislocation in adolescence. This patient was practically disabled by pain and weakness.

PSEUDO-HYPERTROPHIC PARALYSIS may be mentioned as causing a somewhat similar gait and attitude, but here the resemblance ceases.

As has been stated, the diagnosis of congenital dislocation can be easily made by physical examination; the only real difficulty is experienced in early infancy when the dislocation may be incomplete, but opportunity for such early diagnosis is rarely offered.

In doubtful cases a Roentgen picture will demonstrate the character of the disability. (Fig. 260.)

Treatment.—Dupuytren in 1829, after a careful study of the anatomy of the deformity, made the statement that it was not only incurable but that palliation of its effects even was hardly attainable; and for sixty years the statement remained practically undisputed.

The term dislocation naturally suggests that cure can only be attained by replacement of the displaced bone in its proper place, and in 1890 Hoffa of Würzburg first performed this operation with success, by opening the joint from behind and enlarging the rudimentary acetabulum to a size sufficient to contain the head of the bone. Since this time the details of the operation have been modified, particularly by Lorenz of Vienna,[1] who has written the most complete works on the subject.

The radical cure of the dislocation can be accomplished by several procedures:

[1] Pathologie und Therapie der Angebornen Hüft Verrenkung. Wien, 1895. Ueber heilung der Angebornen Hüftgelenk Verrenkung. Leipzig u. Wein, 1900.

1. The open operation with direct enlargement of the rudimentary acetabulum.

2. Forcible replacement and gradual reformation of the joint by functional use.

3. The intermediate operation.

The Open Operation.—As a preliminary treatment the head of the bone must be drawn down to a point corresponding to its normal position, so that the trochanter is on the level of Nélaton's line or even below it. In the older subjects, traction in bed by means of adhesive plasters and the weight and pulley, as described in the treatment of hip disease may be employed for this purpose with advantage. (See page 269.) From 10 to 40 pounds of weight may be used according to the age of the patient and the resistance of the tissues. In using this strong traction, excoriations must be guarded against by constant supervision and readjustment of the perineal bands, and by lessening the weight from time to time when it causes discomfort. In younger subjects the tissues may be sufficiently stretched by manual force at the time of operation.

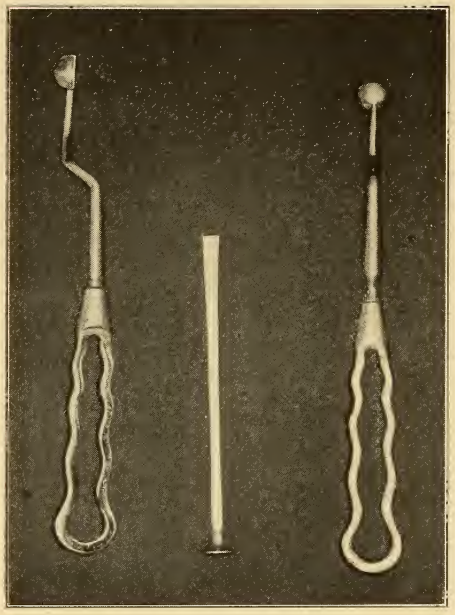
A folded sheet is passed beneath the perineum, the two ends of which are held by an assistant at the head of the table, and by means of intermittent and continuous manual traction the resistance of the contracted parts is overcome. The traction machine of Lorenz may be used for the same purpose, but, as a rule, the preliminary extension in bed is to be preferred to the use of extreme force at the time of operation. When the tissues are sufficiently relaxed to allow the trochanter to be drawn down to its normal position, the joint is exposed by a lateral incision about three inches in length, extending downward from a point about three-quarters of an inch to the outer side of the anterior superior spine of the ilium, the fascia is divided and the line of junction between the tensor vaginæ femoris and the gluteus medius muscles is found. These muscles are then separated and are drawn to either side by retractors, thus exposing the capsule of the joint. The ilio-psoas muscle, which often covers its anterior surface, is separated from it and the capsule is opened by an incision parallel to the neck of the bone. The finger is then passed through the opening, down upon the rudimentary acetabulum. A strong cervix dilator is then inserted and the contracted capsule is thoroughly stretched. If the ligamentum teres is present, it is removed; a large sharp spoon is then introduced by the side of the finger and the acetabulum is enlarged to its normal size by removing from its interior the fibrous tissue, fat and thickened cartilage. If the acetabulum appears to be of sufficient size, as is not infrequent in young subjects, this procedure may be omitted, but in such an event the danger of redisplacement is greater and the limb must be fixed in an attitude of flexion and abduction, as described in the functional weighting method. (See the intermediate operation.)

If the head of the bone is extremely irregular it may be remodeled, but this is rarely necessary. If there is marked anterior rotation of the neck upon the shaft, the head should be replaced in the acetabu-

lum, the leg being rotated inward to a sufficient degree to prevent redisplacement. Later, by means of a simple linear osteotomy below the trochanter minor, the shaft may be rotated outward and the normal relation of the parts restored. In six instances I have found this secondary operation to be necessary. (See osteotomy.)

After the head has been replaced the wound may be closed, but if the acetabulum has been excavated a small opening should be left for drainage as the serous discharge is usually considerable in amount.[1] A plaster of Paris spica bandage is then applied, the leg being fully extended, somewhat abducted, and rotated as a rule slightly inward, so that the head of the bone may be completely contained within the new acetabulum. The first bandage usually remains in position for about eight weeks; it is then replaced by one which reaches to the knee only, and the patient is encouraged to bear the weight on the limb. At the end of another month or longer, when it may be supposed that repair is complete and when the joint is no longer sensitive to direct manipulation, the spica is removed. If possible regular massage and methodical exercises with the aim of stimulating and strengthening the disused and misplaced muscles, should be begun and continued for a year, or longer if necessary.

FIG. 262.



Scoops used in the treatment of congenital dislocation, also the subcutaneous osteotome.

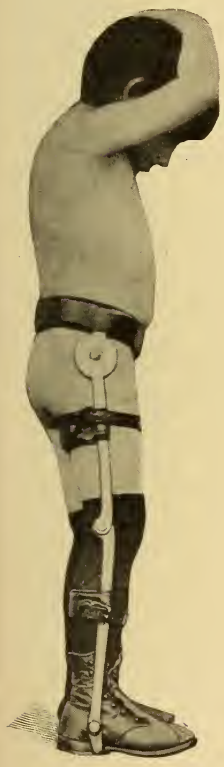
After the open operation the range of motion is at first much limited and forced manipulation causes pain. There is also in many instances a tendency toward flexion and adduction. This is due in part to the original traumatism of the operation, in part to the weakness of the abductor and extensor muscles, and in some instances to the depression of the neck of the femur that may be present.

This tendency toward deformity must be resisted by massage and manipulation and by the use of apparatus if necessary. A useful form of appliance for the purpose of holding the leg in the proper attitude, is a simple jointed leg brace attached to the shoe and to a pelvic band. (Fig. 263.) If the contraction is resistant forcible manipulation under anæsthesia may be required.

[1] Hoffa does not close the wound, but packs it lightly with gauze.

After the operation the legs may be equal in length, but there is as a rule a shortening of about a half inch caused by the excavation of the acetabulum and by the depression of the neck of the bone. A limp persists for a year at least and usually longer, the successful functional result being dependent upon the age of the patient and upon the care that has been exercised in the after-treatment. As a rule traces of the former disability will remain in most instances throughout

Fig. 263.



A successful result after the open operation. Shows a useful form of brace to be used in the after-treatment.

Fig. 264.

Eight months after operation by the open method.

Fig. 265.

Bilateral dislocation six months after replacement by the open method. Illustrating the change in the contour of the trunk.

life because of the abnormalities of the head and neck of the bone or elsewhere, but in a large proportion of suitable cases, practical cure may be obtained, and in all the progress of the deformity may be checked and the symptoms relieved because the head of the bone has been provided with a secure resting place in its normal position. Relapse is unusual if the operation has been properly conducted, unless the neck of the bone is displaced forward in its relation to the shaft so

that it may be impossible to retain the head in the acetabulum unless the foot is rotated inward.

The danger of the operation is slight, and the deaths with but few exceptions have been due to infection. Lorenz and Hoffa lost several of their earlier patients from this cause, but with improved technique the danger is slight.[1] The bad results of the operation may, as a rule, be accounted for by its improper performance, particularly the failure to replace the femur securely, or by failure to insure asepsis, or by inefficient supervision and after-treatment.

It is perhaps unnecessary to state that operations of this character should not be performed unless asepsis can be assured, unless the operator is familiar with the anatomy of the parts and unless the essential after-treatment can be provided.

The prognosis in bilateral displacement is much less hopeful than in the single displacement for the evident reason that the original disability as well as the chances of operative mishap are twice as great.

Reduction of the Dislocation without Open Operation. The "Functional Weighting Method of Lorenz."—The Lorenz treatment is based upon the theory that if parts about the joint may be sufficiently stretched to allow the head of the bone to be brought into direct contact with the rudimentary acetabulum, and if it can be held in this position, the weight of the body, in walking, constantly forcing the bone against the substance that partly fills it, will gradually enlarge it to its normal capacity; thus it is called the "functional weighting" method, and this is its essential and vital distinction from the forcible correction of Paci, with which it is often confounded.

The steps of the operation are: 1. Elongation of the limb.—The trochanter must be brought down to the level of Nélaton's line or lower. This may be accomplished by preliminary traction in bed with heavy weights, or by manual force at the time of operation, the latter means being efficient in young subjects. The child having been anæsthetized, a folded sheet is passed between the legs and the two ends are held above the shoulder of the side to be operated upon, or the assistant may clasp his hands about the perineum and thus fix the pelvis. One then seizes the thigh and begins a series of alternate stretchings and relaxations, using gradually increasing force for from ten to twenty minutes, or until the resistance of the tissues is entirely overcome. The leg is then as long or longer than its fellow and lies limp in an attitude of abduction.

For this preliminary extension Lorenz uses a powerful machine attached to the leg by means of a band about the ankle, but I am inclined to think that the manual method is to be preferred if one does not object to the labor that it involves.

2. Reposition.—One now attempts to force the head of the femur

[1] Hoffa has performed the operation 248 times with 10 deaths—8 due to the operation, the last 132 operations without a death. Lorenz in 260 operations lost 4 patients from septicæmia.—Report of the Thirteenth International Congress, Paris, August, 1900.

over the ridge that represents the posterior margin of the acetabulum and through the opening in the contracted capsule.

The thigh is flexed to about ninety degrees in order to relax the capsule; it is then gradually and forcibly abducted under traction to the limit of the range, or slightly beyond even, so that the head and neck of the bone may lie in the same plane with the side of the pelvis; the thigh is then rotated slightly inward so that the head of the bone may point toward the opening in the capsule, and while traction upon the thigh is continued with one hand the other exerts pressure upon the trochanter and head of the displaced bone, which is then lifted and drawn over the obstacle formed by the rim of the acetabulum. If this is successfully accomplished one hears and feels a distinct sound and shock, and the leg remains fixed in an attitude of flexion and abduction. From this semi-replacement the bone is at once displaced when the leg is adducted or extended.

FIG. 266.

Unilateral dislocation, showing the attitude in the early stage of the Lorenz treatment.

3. ACETABULUM FORMATION. — One now attempts to enlarge the opening of the acetabular part of the capsule. While the head of the bone is forced against or through the opening, the thigh is forcibly rotated outward again and again, and extended to its full limit, in order that the anterior wall of the capsule, which is drawn tightly across the depression, may be distended and the capacity of the new articulation increased. Finally, the patient is turned upon the side and direct pressure is exerted on the trochanter while the limb is alternately flexed and extended.

When the manipulation is completed, the leg is fixed in the attitude of extreme abduction, moderate flexion and inward rotation, by a firm plaster spica bandage extending to the knee, or preferably, slightly below it, the leg being flexed somewhat on the thigh. This longer bandage insures better fixation, and prevents the tendency to outward rotation, although it interferes somewhat with locomotion.

At the time of operation one is able to make a fair prediction as to

its outcome from the character of the reposition and its stability. In some instances the head of the bone seems to be actually replaced in a sufficient cavity, in others, it appears to slip from side to side with but little indication of fixation.

In properly selected cases the operation is free from danger,[1] and the

FIG. 267.

Unsuccessful treatment by forcible correction. (Lorenz operation.) The posterior has been changed to an anterior displacement. Rear view.

[1] Several deaths from the anæsthetic employed have been reported, three of these by Lorenz, and a number of accidents have been caused by violence in the attempt to reduce the displacement in adolescents.

pain and discomfort are much less than one would expect after the force that has been employed. Occasionally there is some discoloration about the adductor region, but this is practically the only noticeable evidence of the manipulation.

As soon as possible the child is encouraged to stand and to walk, the awkwardness caused by the extreme abduction being somewhat lessened by a cork sole, an inch or more in thickness, on the other shoe.

The first bandage should remain in place, if possible, for six weeks or longer. When it is removed, one examines the relation of the parts; if the reposition has been unsuccessful the head of the bone may be felt beneath the anterior superior spine; the posterior has been transformed simply into an anterior displacement. In such cases the operation may be repeated, but in my own experience the secondary operation has never been successful. If the head of the bone appears to be in its proper position, the bandage is again applied. At the end of another month or more, and with each successive change thereafter, the extreme attitude of abduction may be somewhat lessened, until, at the end of eight or ten months, the normal attitude of the limb is restored. The plaster bandage is then removed, but it is well to replace it by a simple jointed brace attached to the shoe and to a pelvic band, by this means the foot may be rotated slightly inward and moderate pressure may be exerted on the trochanter. (Fig. 263.)

During the course of treatment a failure in reposition usually becomes evident, and in any event success is not assured until after all support has been removed. Roentgen pictures are, of course, of service in showing the true relation of the parts, if they are available.

As this operation was first performed in 1895, sufficient time has not elapsed to report definitely upon final results. But in selected cases I am inclined to believe that about 25 per cent. of the patients may be cured by this means alone. The treatment of bilateral displacement by this method is less satisfactory. As a rule it is advisable to operate upon but one hip at a time.

It should be stated that a method of forcible correction, preceding that of Lorenz, was introduced by Paci of Pisa in 1887.[1] Another, and somewhat similar, system is practiced by Schede.[2] As these methods are less definite and satisfactory than that of Lorenz, a detailed account of them is unnecessary.

If the simple operation is unsuccessful, it must be supplemented by the open method. This will be necessary in the larger proportion of cases, particularly in older subjects, but the second operation will be much simpler and more easily performed because the preliminary treatment will have improved the relation of the parts.

The great advantage of this treatment is, that it can be applied as soon as the diagnosis is made, for being free from danger and not necessitating a cutting operation or confinement to a hospital, the consent

[1] Archiv di Ortop., 1892, p. 420.
[2] Archiv f. Klin. Chir., Bd. 43, 1892.

of parents is readily obtained; this is certainly not true of the older method. There is also another advantage, in that the muscles become accommodated to the changed relations of the parts while the leg is fixed by the plaster bandage, so that the long-continued supervision and gymnastic training, that are essential after the open operation, may be dispensed with. Even if the operation has merely resulted in changing a posterior into an anterior displacement, it may be classed as a half cure, since the deformity of the spine is checked and the shortening of the leg is much reduced.

FIG. 268.

Unilateral dislocation. Two years after operation by the Lorenz method. A complete cure.

FIG. 269.

Unilateral dislocation. Eighteen months after operation by the Lorenz method. A complete cure.

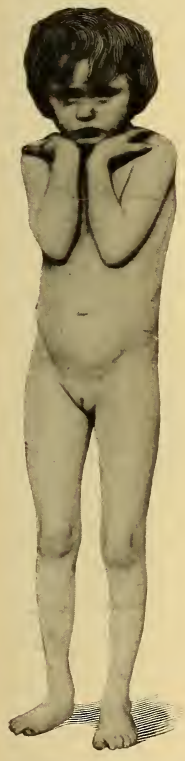
The Intermediate Operation.

The uncertainty of the forcible operation on the one hand and the limitation of motion and distortion that may follow the enlargement of the acetabulum on the other, suggest the desirability of an intermediate

operation which may combine in some degree the advantages of each. Such is the operation of simple replacement by means of open incision.

The operation is identical with that described except that the acetabulum is not enlarged, and that the further details of the non-bloody operation are followed. The limb is fixed in a position of abduction and inward rotation, although not in as extreme degree as when the open incision has not been employed.

Fig. 270.



Unilateral dislocation. After operation by the Lorenz method. A complete cure. Compare with Fig. 255.

Secondary Osteotomy.

If on examination during the open operation the neck of the femur is found to be anteverted to a marked degree, its relation to the shaft must be restored, otherwise the anterior displacement is inevitable when the limb is replaced in the proper attitude. To accomplish this the shaft of the femur may be divided by the subcutaneous osteotome just below the trochanter minor, a long slender drill is then inserted through the trochanter into the neck of the femur. This controls the upper fragment and indicates its position. The shaft is then rotated outward to the proper degree and a plaster spica bandage is applied, through which the drill projects. In a few days it may be removed. The details of the after-treatment do not differ from those of the ordinary cases.

Fig. 271.

Unilateral dislocation. Two years after operation. Compare with Fig. 256.

Review of the Treatment of Congenital Dislocation of the Hip.—The prospect of success in treatment stands in direct relation to the age of the patient, since the extent of the pathological changes that make cure difficult or impossible, depends in some degree, as in acquired dislocations, upon the duration of the disability. Consequently treatment should be applied as soon as the displacement is discovered, and, as has been stated, there is little excuse for not making the correct diagnosis as soon as the child begins to walk. The treatment of selection, before the age of six years, is the functional weighting method of Lorenz. By this means a certain proportion of the cases may be cured, and in all instances the posterior may be changed into an anterior displacement, which makes the after-treat-

ment much easier. If this treatment is ineffective, it should be followed by the open method. In the younger patients, simple incision and forcible stretching of the capsule may be sufficient, if the acetabulum is well formed; if not, it will be necessary to enlarge it to the normal size. The same system may be followed in older children, but the simple correction is much less likely to be successful although cures have been reported at ages far beyond this limit. As a rule then, in this older class the open operation may be performed primarily, the operation being preceded if possible by traction in bed, so that all contractions may be completely overcome. In patients beyond the age of ten years the prognosis is very doubtful, although the treatment may be attempted in suitable cases.

All other methods of treatment, by long-continued traction in bed, by braces for support or pressure—by tenotomy and scarification of the part—by "sclerogenous injection" and the like, have been practically abandoned.

For simple palliation a corset which lessens the exaggerated lordosis and provides pressure over the trochanters is of some service in the double dislocation. Some form of brace attached to the shoe by which the weight of the body is supported on a perineal strap as described in the treatment of the convalescent stage of hip disease, and which exerts pressure on the trochanter may be employed in the single form supplemented by exercises and by massage. By such means the progress of the deformity may be checked and some improvement in the position and stability of the bone may be assured, although increase of the deformity may be expected when the treatment is discontinued. A "high shoe" to equalize the length of the limbs, to lessen the limp and to prevent permanent distortion of the spine is indicated also. Over-exertion and laborious occupations should be avoided. This is of especial importance during childhood and adolescence when the tendency toward an increase of the disability is most apparent.[1]

Coxa Vara.

Synonyms.—Depression or incurvation of the neck of the femur. Bending of the neck of the femur.

The character of this deformity is indicated by the synonyms, while the term coxa vara signifies that its causes and effects are similar to those of genu valgum and varum, the more common distortions of the lower extremities.

Genu valgum and varum are common in childhood, but rarely develop in adolescence. Coxa vara is, in comparison, not only an infrequent deformity, but it is peculiar also in that it more often appears in later childhood or adolescence than at the earlier period, doubtless because the neck of the femur is, at the age when rhachitic distortions are common, very short and is relatively stronger than the shaft, while in adolescence the conditions may be reversed.

[1] The bibliography of the subject may be found in the volumes of the Zeits. für Orth. Chir.

The distortions at the knee are self evident, but the neck of the femur is concealed from view, thus the diagnosis of coxa vara may be somewhat difficult; and in fact, it is only in very recent years that its symptoms have been recognized. Fiorani[1] first described the deformity as it had been observed by him in children, but E. Müller[2] first called attention to the affection as one of the deformities of adolescence, which, until that time, had been mistaken for hip disease.

Pathology.—The term coxa vara should not be applied to depression of the neck of the femur that may be secondary to destructive disease; for example, to osteomyelitis, arthritis deformans and the like, but it should be reserved for cases of simple local deformity. In most instances the deformity affects the neck as a whole, in others it is most marked at the epiphyseal junction. A number of specimens have been examined but no changes, other than such as might be caused by the deformity itself, have been found. These are, in brief, congestion and softening of the bone, and evidences of irritation within the joint during the progressive stage of the deformity and the general adaptive changes in all the components of the joint that always accompany displacement or distortion.

FIG. 272.

Section of the upper extremity of a normal femur at eight years of age; angle formed by the neck with the shaft 140 degrees. In the normal subject the neck of the femur projects slightly forward (12 degrees), and upward to form an angle with the shaft of about 125 degrees. In childhood this angle is usually somewhat greater, and in later years it may be somewhat less than 125 degrees; in fact a variation between 110 and 140 degrees may be within the normal limit.[3]

Etiology. — Some writers assume that the weakness of the neck of the femur that induces the deformity is the result of local disease such as so-called local rickets, or local osteomalacia. This is however simply a convenient hypothesis. Others believe the deformity to be symptomatic of late rickets; but evidence of general rhachitis is almost never present in the ordinary type of cases.

Coxa vara is one of the group of static deformities of the lower extremity caused by a disproportion between the strength of the supporting structure and the burden that is put upon it. The support may be disproportionately weak because of inherited delicacy of structure, or it may be weakened by injury or by disease, or over-burdened by weight or strain.

MECHANICAL PREDISPOSITION TO DEFORMITY.—In many cases the predisposition to deformity is the result of a lessened angle of

[1] Gazetta degli Ospitale, Nos. 16-17, 1881.
[2] Beiträge zur Klin. Chir., 1889, Bd. 4.
[3] Humphrey, Jour. Anat. Phys., Vol. XXIII., p. 236.

the femoral neck. This slight and predisposing depression which appears to be, in many instances, the effect of early rhachitis, becomes exaggerated to deformity during later childhood or adolescence. The importance of this mechanical factor in the etiology was demonstrated to me by the investigation of a number of cases of simple fracture of the neck of the femur in childhood. In these cases the neck of the femur was, by the original injury, somewhat depressed, and although complete functional recovery followed, yet in a number of the cases, progressive deformity, attended by the symptoms of typical coxa vara, resulted. This could be explained only on the theory that the lessened angle, subjecting the part to greater strain, was the predisposing cause of the later disability. Other factors in the etiology may be general weakness, incident to rapid growth, direct injury or the strain of occupation.[1]

In this connection it may be stated that fracture of the neck of the femur in childhood may cause a deformity which in the absence of a history could not be distinguished from the ordinary form of coxa vara, of which in fact, it is the traumatic form. (See fracture of the neck of the femur.)

Statistics.

The deformity is far more often unilateral than bilateral and more than three-fourths of the cases are in males. In a total of 109 cases collected from the literature, including 39 personal observations, 83 were in males and 26 in females; 85 were unilateral and 24 were bilateral. The more important details in the 39 cases that have come under my observation, are presented in the accompanying table.

The points of especial interest may be summarized as follows: In about one-third of the cases there was a distinct history of rhachitis in infancy. The ages at which the symptoms became noticeable appeared to be as follows:

Adolescents, 12 to 17	20
Later childhood, 5 to 11	13
Early childhood, less than 5	5
Unknown	1
Total	39

29 of the patients were males, 10 were females. In 33 cases the deformity was unilateral, in 6 it was bilateral. In 34 cases the neck of the femur was distorted in a direction backward as well as downward, in 2 directly downward, in 3 forward and downward. In each case of the last group the deformity was bilateral. (See table, page 395.)

Symptoms. 1. Mechanical Effects.—The character of the symptoms may be explained by a description of the distortion and of its direct effects upon the function of the joint. When the neck of the femur is depressed, for example, to a right angle with the shaft,

[1] One case of congenital coxa vara has been reported by Kredel (Cent. für Chir., N. 42, 1896). Depression of the neck of the femur in congenital dislocation of the hip has been mentioned in the section on that affection.

Name.	Date.	Sex.	Side affected.	Age.	Duration.	Direction of the distortion forward or backward.	Actual shortening in inches.	Apparent shortening.	History or evidence of former rhachitis.
1 Nelson	Oct. 1896	F.	R.	2½	6 months	Post.	½	½	Yes
2 Van Orden	June 1896	M.	R.	4	1 year	Post.	¾	¾	No
3 Zeltermann	Jan. 1898	M.	R.	7	6 months	Post.	½	½	Yes
4 Vitt	Mar. 1897	M.	L.	7	6 months	Post.	1	1	Yes
5 Tuit	July 1899	F.	L.	7½	6 months	Post.	½	¾	Yes
6 Seeger	Mar. 1897	F.	L.	8	2 years	Post.	1	1	No
7 Rose	Jan. 1888	F.	D.	8	3 years	Post.	—	—	No
8 Cohen	June 1898	M.	R.	8	6 months	Post.	½	½	Yes
9 Kebesky	Aug. 1900	M.	L.	8	6 months	Down'd	½	½	Yes
10 Dengher	July 1900	M.	R.	8	1 year	Down'd	½	½	Yes
11 Hirsch	Mar. 1897	M.	D.	9	2 years	Ant.	—	—	Yes
12 Reardon	Mar. 1898	M.	D.	11	6 years	Ant.	—	—	Yes
13 Beckmyer	Mar. 1895	M.	D.	11	8 years	Post.	—	—	Yes
14 Brill	Mar. 1894	M.	R.	11	1 year	Post.	1	1	No
15 Greer	Jan. 1896	M.	L.	12	8 years	Post.	1	1	Yes
16 Thomas	Mar. 1898	F.	D.	12	1 year	Ant.	R. ¾	¾	Yes
17 Abrams	Mar. 1898	F.	R.	13	10 years	Post.	2	2¼	No
18 Rutschmann	July 1896	M.	R.	13	6 months	Post.	½	½	No
19 Fraad	Nov. 1894	M.	R.	13	1 year	Post.	¼	¼	No
20 Shandley	Dec. 1898	F.	R.	13	1 year	Post.	½	1½	——
21 Skidmore	Nov. 1899	M.	L.	13	3 years	Post.	½	1½	——
22 Cords	May 1900	M.	R.	14	3 months	Post.	½	1½	Yes
23 Cunningham	May 1897	F.	L.	14	1 year	Post.	½	1½	No
24 Herbert	Apr. 1897	M.	R.	14	6 months	Post.	1	1	No
25 Bruning	Oct. 1897	M.	R.	15	2 months	Post.	½	1	No
26 Betz[1]	June 1892	M.	R.	15	1 year	Post.	¾	3	No
27 Lawson	Oct. 1897	M.	R.	15	1 year	Post.	½	1¼	No
28 Rose	Jan. 1896	M.	L.	15	14 months	Post.	¾	¾	No
29 Allen	Apr. 1897	M.	L.	16	1 month	Post.	1	1½	No
30 Puckhaber	June 1893	M.	D.	16	8 months	Post.	—	—	Yes
31 Gieger	May 1900	M.	L.	16	6 months	Post.	½	1¼	No
32 Schade	July 1898	M.	L.	16	18 months	Post.	1	1	——
33 Morris	Jan. 1900	M.	R.	17	6 months	Post.	¼	¼	No
34 Jocker	Dec. 1899	M.	L.	17	1 month	Post.	½	½	No
35 Beck	July 1898	F.	R.	17	1 year	Post.	1½	1½	No
36 Zimmermann	Oct. 1896	M.	R.	17	13 months	Post.	¾	2¼	No
37 Fessner	Mar. 1894	M.	L.	17	6 months	Post.	¾	¾	No
38 Enderlich	Jan. 1897	F.	R.	22	1 year	Post.	¾	1	No
39 Adult	Mar. 1896	M.	R.	36	.....	Post.	1	1½	No

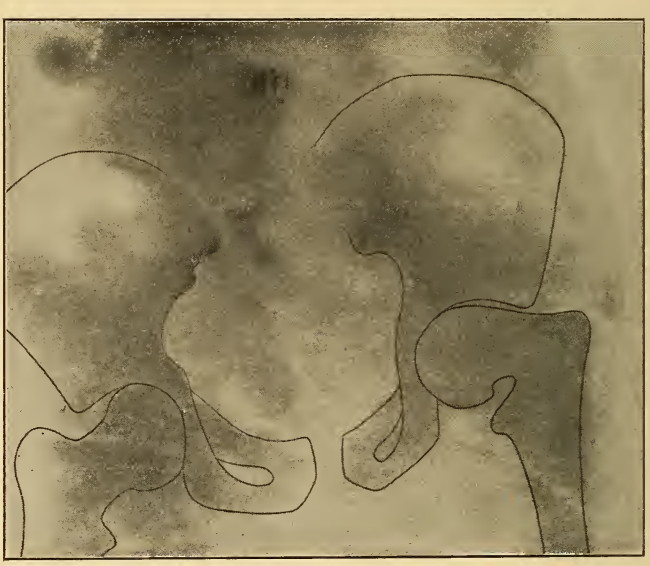
the trochanter is elevated to a corresponding degree above Nélaton's line and forms a noticeable projection as contrasted with the normal contour (Fig. 276), a projection that becomes more marked when the thigh is flexed and adducted. (Fig. 275.) In most instances the neck is displaced backward as well as downward, following the line of least resistance, and as the head of the bone remains in the acetabulum the trochanter is thrown forward and the limb is rotated outward. The ability to abduct the thigh is dependent upon the length and upon the upward inclination of the femoral neck (Fig. 154); when, therefore, this inclination is diminished the range of abduction is lessened, in part by the greater tension that is exerted upon the lower portion of the capsule, in part by the direct contact (Fig. 273) of the rim of the acetabulum with the neck and trochanter and in part by the adaptive contractions that always accompany displacements of this character. It is evident also that the distortion of the neck backward and downward changes the relation of the acetabulum to the head of the bone, so that abduction or flexion tends to displace it from its socket. Thus the range of abduction, of inward rotation and of flexion is limited, while that of adduction, outward rotation and extension, may be increased.

There is actual shortening of the limb dependent upon the upward displacement of the shaft of the femur; this is not often more than an inch in the ordinary type of adolescent deformity, but the apparent shortening, caused by the adduction and the accommodative upward tilting of the pelvis, may be extreme, from two to three inches is not uncommon. (Fig. 276.)

2. Physical Effects.—The symptoms of coxa vara of the ordinary form, are : **Discomfort, awkwardness, limp, shortening, atrophy, limitation of motion, deformity.**

Coxa vara is a more disabling deformity than genu varum or valgum and its attendant symptoms of discomfort, weakness and pain, are, as a rule, more marked. This is explained by the fact that in

Fig. 273.



Skiagram of coxa vara, deformity most marked at the epiphyseal junction. This illustrates the mechanical limitation of abduction caused by the deformity, and the compensatory tilting of the pelvis. The patient is shown in Fig. 276.

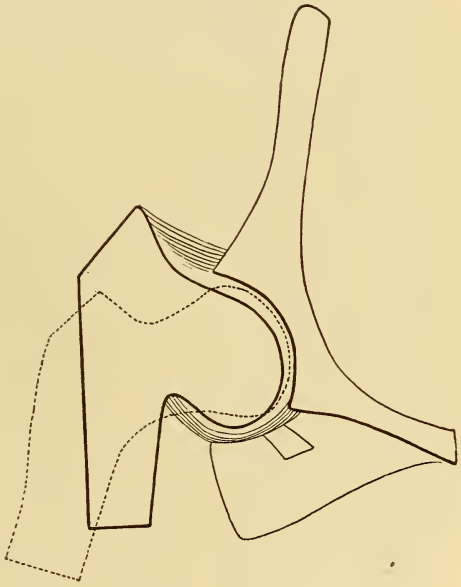
coxa vara, the head of the bone is in part displaced (Fig. 274) from the acetabulum, while in the deformities at the knee the joint surfaces remain in practically normal relation to one another.

The symptoms of **unilateral coxa vara** vary with the degree and with the duration of the deformity. The patient usually complains of sensations of stiffness and weakness, referred to the thigh. These are more noticeable on changing from a position of rest to one of activity and at times, particularly after over-exertion, there may be actual pain. By far the most important symptom and the one that almost always induces the patient to seek treatment, is the limp. This limp accompanied, as it usually is, by outward rotation of the foot, resembles that caused by fracture of the neck of the femur. On physical examina-

tion the actual shortening, explained by the elevated and prominent trochanter and the peculiar unequal limitation of motion, will make the diagnosis clear. In some instances there may be a slight degree of muscular spasm and there is usually some atrophy of the muscles of the thigh.

Bilateral Coxa Vara.—If the deformity is bilateral its effect upon the gait and attitude is more marked. The gait is extremely awkward, resembling somewhat that of knock knees, for the limitation of abduction forces the patient to sway the body from side to side in order that the legs may pass one another, and if the deformity is extreme the limbs may be crossed over one another, so that locomotion may be difficult. Bilateral coxa vara is not infrequently accompanied by other deformities, as, for example, knock knee or flat foot. (Fig. 277.)

FIG. 274.



Cross section of the pelvis and the deformed femur. A scheme to show the effect of the deformity in limiting abduction of the limb. The dotted outline shows the normal relation.

OTHER VARIETIES OF COXA VARA.—In rare instances the neck of the femur may be depressed directly downward or even downward and forward. In the latter instance the effect of the deformity upon the function of the joint is somewhat different from that of the ordinary type. Abduction is limited as in the common form, but inward rotation replaces outward rotation and extension is limited in place of flexion. This type of deformity is almost always bilateral. It is accompanied, usually, by slight permanent flexion of the thighs; thus the lumbar lordosis is exaggerated, whereas, in the ordinary form, it is usually lessened.

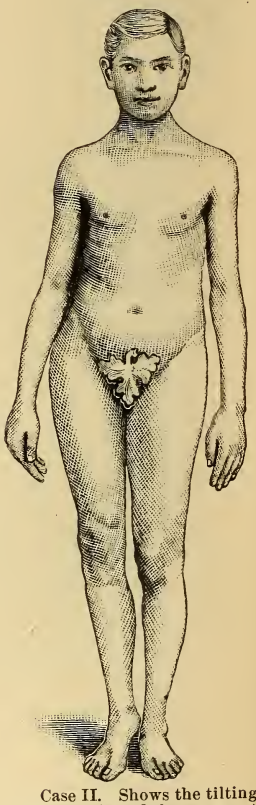
This description applies to the ordinary types of the deformity as it is seen in later childhood and in adolescence. It undoubtedly occurs in early life, but it is masked by the more noticeable distortions of other parts, and as an isolated deformity that demands treatment, it is rare. One case was observed by the writer in a rhachitic child two and one-half years of age. The symptoms, though slight, were typical, and the diagnosis was confirmed by a Roentgen picture. In other cases seen in later childhood, the history of more or less discomfort for many years, seemed to indicate that the deformity was caused directly by rhachitis.

In the majority of cases the symptoms begin insidiously although in many instances they may be ascribed to injury or to over-exertion. If the affection begins in adolescence and is untreated, the period of discomfort during which the depression of the neck may be assumed to be progressive, is from one to three years; but if the deformity appears at an early age, the symptoms, though remittent in character, may continue indefinitely. When the resistance of the compressed bone

FIG. 275.

Coxa vara, showing prominent trochanter.

FIG. 276.



Case II. Shows the tilting of the pelvis and the apparent shortening of the leg in unilateral coxa vara. Actual shortening ¾ inch; apparent shortening 2½ inches. See skiagram (Fig. 273).

becomes sufficient to insure stability, the discomfort ceases and the disability becomes less marked, as Nature accommodates the mechanism to the new conditions.

Diagnosis.—In most instances diagnosis may be easily made, and yet coxa vara is very often mistaken for **hip disease**; in fact we are indebted to this mistake for most of the specimens of the deformity that have been described. The essential differences between the two

are as follows: In tuberculous disease of the hip the motions of the joint are limited in every direction by reflex muscular spasm, and as a rule, other evidences of the character of the disease are apparent. Coxa vara is a simple deformity; reflex muscular spasm is absent, except during exacerbations due to injury or over-strain, and movement is not limited in all directions, but only in abduction, flexion and inward rotation when the deformity is of the ordinary type. Actual shortening is a late symptom of hip disease, while it is present from the very onset of coxa vara. It is a shortening explained by the elevation of the trochanter above Nélaton's line, while such elevation in hip disease is a sign of destruction, either of the head of the bone or of a part of the acetabulum.

Fig. 277.

Double coxa vara of advanced degree, showing the involuntary crossing of the legs in flexion.

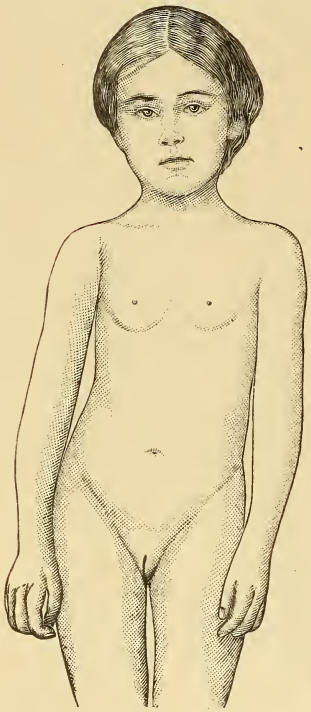
The deformity might be readily mistaken for **congenital dislocation of the hip**, particularly of the anterior variety, but this would be excluded by the history, since coxa vara is an acquired deformity. The diagnosis between the two affections may be easily made on the physical signs alone. In congenital dislocation, if the leg be flexed and adducted to its extreme limit, the head and neck of the displaced bone can be distinguished beneath the distended tissues of the buttock. In coxa vara, nothing but the prominent trochanter can be made out on similar manipulation, while the abnormal mobility, characteristic of the dislocation, is absent.

Treatment.—If the deformity were discovered in the early stage, one might hope to check its progress by a change in the surroundings and occupation of the patient. Standing, particularly in the attitude of rest, which throws additional weight upon the weakened part, should be avoided, and work of any kind that induces the familar symptoms of strain should be discontinued. As much time as possible should be spent in the open air, and diet and proper therapeutic remedies should be employed if evidence of constitutional weakness or rhachitis is present. Locally massage of the limbs and joints and forcible manipulation, with the aim of overcoming as much of the adduction as may depend upon the secondary changes in the soft parts, should be employed, reinforced by regular gymnastic exercises of the legs, with the object

of improving the circulation upon which the repair of the weakened bone depends.

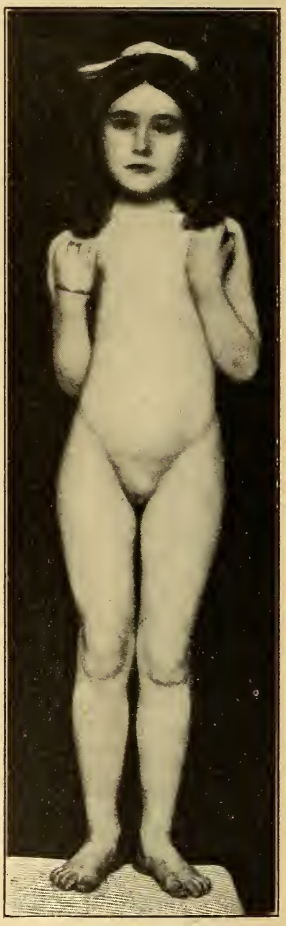
In most instances of unilateral deformity temporary support is indicated. A perineal crutch (Fig. 204) or, if the circumstances of the patient permit, one of the convalescent hip splints that allows motion at the knee, may be used. (Fig. 205.) With support during the time of greatest strain, that is, when continuous walking or standing may be required, combined with proper exercises and massage, the weak part may become sufficiently strong to perform its function in a year or more, but supervision will be necessary for a much longer time.

FIG. 278.



Unilateral coxa vara, showing the effect of slight depression of the neck of the left femur upon the attitude. (See Fig. 279.)

FIG. 279.



The patient, Fig. 278, eight months after cuneiform osteotomy. An absolute cure both as regards symptoms and deformity. See skiagram (Fig. 280).

Operative Treatment.—When the deformity has advanced so that the leg is permanently adducted, operative treatment is indicated.

LINEAR OSTEOTOMY.—The simplest and most efficient means of overcoming the adduction in OLDER subjects is linear osteotomy of the

shaft of the femur just below the trochanter minor. This may be performed by the subcutaneous method, as in the correction of the deformity of hip disease. When the bone has been divided the shaft is rotated inward until the foot is brought to the normal attitude and it is then abducted to the normal limit; in this attitude a plaster spica bandage is applied reaching from the axilla to the toes.

If the deformity is bilateral it is often sufficient to operate on the leg which is most affected. When the fracture is consolidated, massage, exercises and support are employed as has been described. It may be assumed that the increased blood supply necessitated by the repair of the injury will affect favorably the weakened bone as well.

FIG. 280.

Skiagram of patient, Figs. 278 and 279. Illustrating the effect of the operation in replacing the neck of the femur in its normal position.

The final result in two cases, in which the operation was performed by the writer, was very satisfactory.

CUNEIFORM OSTEOTOMY.—IN YOUNGER patients the deformity may be remedied and its progress checked by removal of a cuneiform section of bone from the upper extremity of the shaft at the level of the trochanter minor. (Fig. 281.) In childhood the neck of the femur is short and the strain to which it is likely to be subjected slight, thus operative treatment may be indicated as a prophylactic measure while in adolescence operative treatment may be deferred until the progression of the deformity has ceased.

In the technique of this procedure there are several points of importance. First, all restriction of abduction, of ligamentous or mus-

cular origin, must be overcome by vigorous manipulation before the operation on the bone, otherwise it will be difficult to bring the two fragments into proper apposition. The base of the wedge should be about three-quarters of an inch in breadth, directly opposite the trochanter minor; the upper section should be practically at a right angle with the shaft, the lower being more oblique. (Fig. 281, 2.) The cortical substance on the inner aspect of the bone should not be divided, but, reinforced by the cartilaginous trochanter minor, should serve as a hinge on which the shaft of the femur is gently forced outward, until the opening is closed by the apposition of the fragments after the upper segment has been fixed by contact with the margin of the acetabulum (Fig. 281, 3); thus the continuity of the bone is preserved. The leg is then held in the attitude of extreme abduction, by means of a plaster spica bandage, which should include the foot also, until the union is firm.

The opportunity for treatment of coxa vara, in earliest childhood, is rarely offered. It is usually the direct result of rhachitis and in the early stage, at least, it is probably accompanied by other rhachitic distortions. It would be well, therefore, to examine the hip joints of rhachitic children, especially those who present the deformity of genu valgum with reference to this distortion.[1]

FRACTURE OF THE NECK OF THE FEMUR.

Traumatic Coxa Vara.

Fracture of the neck of the femur in childhood, although until recently unrecognized, is by no means an uncommon accident, since seventeen cases have come under the writer's observation during the past nine years.

Fracture of the neck of the femur in childhood, however, differs markedly in its symptoms and in its effects from that in later life. In childhood the immediate effects of the injury are far less disabling and the patient is often able to walk about within a few days after the accident, from which it may be inferred that there is, in many instances, a bending and breaking of the neck without actual separation of the fragments. During the period of repair the limp and attendant discomfort are usually mistaken for symptoms of hip disease.

The diagnosis is usually simple. In all the cases there is a history of injury, usually a fall from a height, which confined the patient to the bed for several days or weeks. On physical examination shortening of half an inch to an inch is found, explained by the corresponding elevation of the trochanter. Motion in the joint is more or less restrained by voluntary and involuntary contraction of the muscles, but this restriction is much more marked in flexion, abduction and inward rotation than in other directions; a limitation explained by the nature

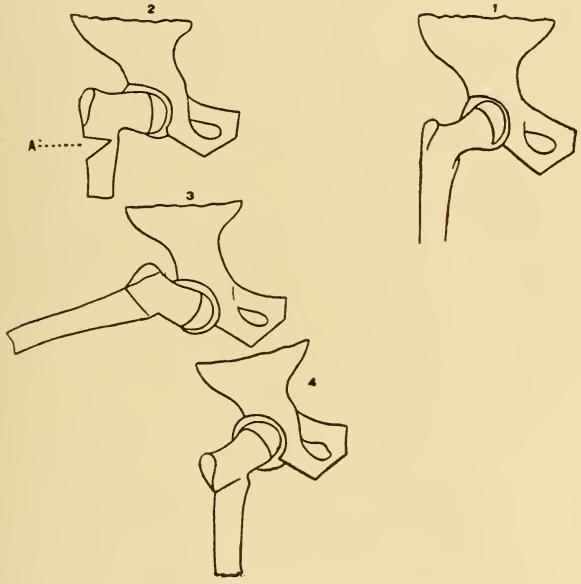
[1] The bibliography of the subject, to the extent of 127 references, may be found in a recent article by Wagner in Zeits. für Orth. Chir., Bd. VIII., H. 2, 1900.

of the displacement, the neck of the bone having been forced downward and backward.

The immediate effect of the injury is, as has been stated, less marked than in the adult, but the tendency of the deformity is to increase in later years, because the right-angled relation of the neck to the shaft exposes it to greater strain. In a number of the patients examined several years after the injury, there was an increase of the actual shortening combined with permanent adduction. At this time the deformity could not have been distinguished, except for the history, from the ordinary coxa vara of a rather extreme degree.

The treatment of the fracture of the neck of the femur, if the diagnosis is made immediately after the accident, should include an attempt

FIG. 281.



1, the normal femur; 2, depression of the neck of the femur—coxa vara; A, a wedge of bone has been removed; 3, abduction of the limb first fixes the upper segment by contact with the rim of the acetabulum, then closes the opening in the bone; 4, replacement of the limb after union is completed elevates the neck to its former position.

to replace the neck in its proper relation with the shaft in order that subsequent deformity may be prevented. This may be accomplished, if at all, by forcing the limb into abduction while traction is exerted, and in this position a plaster bandage, reaching from the axilla to the toes, should be applied.

After consolidation of the fracture a traction hip splint may be worn for several months or until complete repair has taken place. Massage and forcible manipulation, if limitation of motion remains, combined with the avoidance of over-strain, may prevent the increase of the deformity. Otherwise the neck of the femur should be replaced in its normal position by the removal of a sufficient wedge of bone from the

base of the trochanter as described under the treatment of simple coxa vara. (Fig. 281.)

Traumatic Separation of the Epiphysis of the Head of the Femur.— As has been stated, in traumatic depression of the neck of the femur the bone breaks or bends at about the center of the neck, which in childhood is but little more than an inch in length. In exceptional cases the head of the femur may be separated at the epiphyseal line. This disjunction is more likely to occur in adolescence and particularly in subjects suffering from coxa vara in the early stage. Thus sudden disability, following slight injury, in an adolescent who has complained of discomfort and limp for some time before and who presents on examination the signs of depression of the neck of the femur, would lead one to consider the possibility of this accident; but the diagnosis could be established only by a Roentgen picture or by operation.[1]

The treatment is similar to that of fracture, but the functional derangement of the joint is likely to be greater for the reason that the articulating surface of the head of the femur is involved.[2]

[1] Sprengel, Archiv f. Klin Chir., Bd. 47, S. 805, 1898; Clarke, Lancet, Oct. 27, 1900.
[2] Whitman, The Medical Record, July 25, 1893; Annals of Surgery, June, 1897, and February, 1899.

CHAPTER XV.

DEFORMITIES OF THE BONES OF THE LOWER EXTREMITY.

Of the distortions of the lower extremity bow leg and knock knee are by far the most common, comprising about 15 per cent. of the total cases in orthopædic clinics. Of the two, bow leg is the more frequent in all tables of statistics, and it is probable that the proportion of bow leg to knock knee is much larger than would appear from the hospital records; for genu valgum is generally recognized as a serious deformity, while bow leg is known to be of little consequence except from the æsthetic standpoint, so that its rectification is more often trusted to the power of nature.

Both deformities appear to be more common in male than in female children, a fact explained perhaps by the greater weight and the greater susceptibility of the former. But here again statistics may be influenced somewhat by the fact that bow legs are considered to be of more consequence to the boy than to the girl because of the concealment that the skirts will insure, if the distortion is not outgrown in childhood.

Statistics.—The relative frequency of the two deformities may be indicated by the statistics of the Hospital for Ruptured and Crippled for the past ten years. During this time 5,441 cases were recorded, 3,452 cases of bow legs (63.4 per cent.), 1,989 of knock knees (37.6 per cent.). Of the 3,452 cases of bow legs, 2,030 were in males (58.8 per cent.) and 1,422 were in females (42.2 per cent.). The 1,989 cases of knock knees were more evenly divided between the sexes, 1,024 being in males (51.4 per cent.) and 965 in females (48.6 per cent.).

Bow Legs.

	Year.	No. cases.	Males.	Females.	Over 21.	Over 14.
1	1899	400	236	164	0	5
2	1898	406	255	151	0	2
3	1897	467	268	199	4	1
4	1896	356	200	156	0	1
5	1895	336	200	136	2	1
6	1894	310	170	140	1	2
7	1893	262	157	105	3	3
8	1892	306	189	117	1	2
9	1891	303	174	129	1	1
10	1890	306	181	125	1	3
		3,452	2,030	1,422	13	21

KNOCK KNEES.

	Year.	No. cases.	Males.	Females.	Over 21.	Over 14.
1	1899	202	120	82	1	4
2	1898	233	135	98	0	11
3	1897	222	120	102	2	5
4	1896	232	101	131	0	0
5	1895	210	109	101	0	2
6	1894	212	86	126	0	0
7	1893	162	80	82	1	2
8	1892	168	89	79	8	2
9	1891	189	92	97	1	2
10	1890	159	92	67	3	3
		1,989	1,024	965	16	29

It will be noted that 45 of the cases of genu valgum were in patients more than 14 years of age, as compared with 34 cases of adolescent or adult bow legs. The writer's personal experience in the clinic enables him to state that a large proportion of the cases of genu valgum actually developed or increased to an extent demanding treatment during adolescence, while most of the cases of bow leg deformity in patients more than 14 years of age had existed since early childhood or were the result of injury or disease.

The Etiology of Genu Valgum, Genu Varum and of Other Distortions of the Bones of the Lower Extremity.—The common predisposing cause of simple deformities and disabilities of the lower extremities, in other words those not caused by local injury or local disease, is the erect posture, when for any reason the bones and the joints are unequal to the strain of locomotion and to the task of sustaining the weight of the body.

TIME OF ONSET.—At two periods of life the deformities under consideration most often develop. The first is in early childhood, when the upright posture is first assumed; the second is in adolescence, when the rapid growth and other changes incident to this period may lessen the stability of the supporting structures, and when the strain of laborious occupation may be added to that of the increasing weight of the body.

The deformities of adolescence are, however, relatively insignificant in number compared with those of early childhood, for in childhood inherited weakness or weakness that is the direct result of malnutrition, at once develops into deformity under the strain of standing and walking. Thus, as a rule, the deformities under consideration first attract attention soon after the child begins to walk, and the patients are usually brought for treatment during the second or third year of life. If the deformities are severe, the body usually presents the evidences of general rhachitis; in other instances the distortion of the legs is the only sign of its presence, and in other cases there may be no evidence whatever of malnutrition or disease.

PREDISPOSITION TO DEFORMITY.—It is not always easy to explain why weak legs bend in one way rather than in another. In some

instances it is probable that a slight degree of deformity is present before the child begins to walk. For example, a slight outward bowing of the legs is said to be common in early infancy, and the use of heavy diapers might favor a continuation of the distortion. Knock knee may be induced, apparently, by holding the infant on the arm with the knees pressed against the chest, and certain cases of knock knee and bow leg combined appear to be caused directly by this manner of carrying the infant habitually upon one arm.

The legs of rhachitic children, who have never walked, are often

FIG. 282.

Habitual posture as a factor in the etiology of rhachitic bow leg.

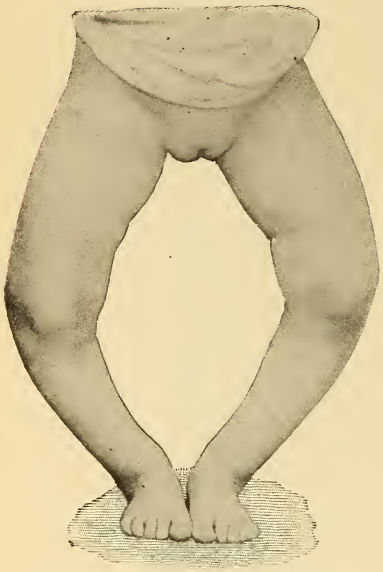
somewhat distorted and in many instances this may be explained by the habitual postures. (Fig. 282.)

A moderate degree of bow leg is not infrequently seen in vigorous infants who stand and walk at an early age. Aside from the determining curve in the bone that may be present before the child begins to walk, this predisposition toward bow leg may be explained, perhaps, by the fact that young infants often separate the feet widely in walking and the swaying of the body from side to side may tend to bend the legs outward. In weaker or less vigorous children a slight degree of knock knee is not uncommon, induced, it may be, by weak-

ness or inactivity of the muscles, as a result of which the child stands with the knees somewhat flexed and pressed together, while the feet are separated and everted, an exaggeration of the so-called attitude of rest.

Bow leg is not uncommon in adult life and it is popularly associated with strength and activity. Undoubtedly the attitudes of activity favor the production of bow leg rather than knock knee, so that this tradition may have a foundation of truth. It is said to be common among those who ride constantly and it may be a direct result of injury or disease of the knee joint, but it may be stated that well-marked bow leg in an adult is almost always a deformity that has existed since childhood. This statement cannot be made of genu valgum, since it may develop or increase during adolescence or even in adult life. The predisposing cause is weakness or overstrain, and as has been stated in the popular mind the deformity is characteristic of weakness.

FIG. 283.



A type of deformity in which the prognosis as regards outgrowth is bad.

THE ATTITUDE OF REST.—Genu valgum is an exaggeration of what is known as the attitude of rest or relaxation, in which the weight of the body is thrown in great part upon the ligaments of the three joints of the lower extremity. In the attitude of rest the pelvis is tilted forward, the femora are rotated inward upon the tibiæ and the feet are separated and everted, so that the greatest strain falls upon the inner side of the knees and of the feet. Thus, what is known as flat foot is often combined with knock knee; knock knee may cause flat foot, but more often the flat foot may induce knock knee, or both may be the effect of the same general cause. Genu valgum, in the slighter degree at least, may be induced directly by an improper attitude, but the attitude is, as a rule, the result of over-work to which the mechanism is subjected; thus the knock knee of adolescence is so common among the bakers of Vienna, that "baker's knee" is there synonymous with genu valgum.

Genu valgum may be secondary to distortion elsewhere. For example, compensatory knock knee is usually combined with extreme adduction of the thigh; it may be the result of the inactivity necessitated by the treatment of hip disease; it may be a direct result of injury, and it is sometimes an accompaniment of osteomyelitis or osteoperiostitis of the tibia, which causes an overgrowth and abnormal lengthening of the leg.

The Outgrowth of Deformity.—In considering the treatment of the simple static deformities of the lower extremity which are usually the result of a temporary weakness of structure, one must first answer the question, "Will not the child outgrow it?" This belief in the spontaneous cure of deformity is very strong not only among the laity but among physicians as well; and it rests upon the common observation that crooked legs become straight, or at least less deformed, with the growth of the child. In fact if one were to judge from the general observation of the effect of growth upon the deformities of this class, or even from the tracings of the legs of rhachitic children taken from year to year, one might conclude that all deformities of this class might be safely left to themselves. As an illustration of positive evidence on the subject, the observations of Kamps,[1] on 32 cases of rhachitic distortion of the lower extremity, may be cited. Four and one-half years after the cases were first seen and recorded, examination showed that 75 per cent. were cured, 15.3 per cent. improved, while 9.7 per cent. were unimproved. His conclusions are that such deformities do not, as a rule, require special treatment in early childhood, but that after the age of six years the prognosis for spontaneous cure is unfavorable.

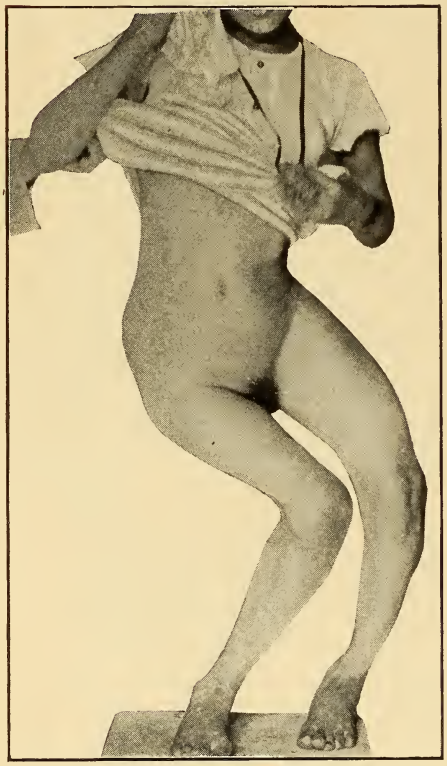
Veit[2] photographed a number of rhachitic children seen in the surgical clinic of the University of Berlin, and after a lapse of two or three years made another series of photographs of the same patients, who had meanwhile received no treatment. His conclusions are similar to those of Kamps, namely, that surgical treatment is not required for deformity of this character in children less than six years of age. In two classes of cases, however, the prognosis for spontaneous cure is not favorable, those in which the growth has been checked by the rhachitic process, and in certain cases of extreme bow legs, "O" legs. (Fig. 283.)

The rectifying force of nature acts in two ways. Assuming that the deformity reached its limit during the period of original weakness, it must of course become relatively less as the body increases in length and size. In fact the outgrowth of deformity has a direct relation to the rapidity of growth during the early years of childhood. The second manifestation of the power of nature is more positive. It may be assumed that when the deformity is progressive all the tissues are affected by the weakness, consequently the attitudes of the child are those that can be most easily assumed under the abnormal conditions. But when the primary cause of the weakness, in most instances rhachitis, is no longer operative, the muscles take on new activity and vigor and the actions and attitudes, in spite of the deformity, become approximately normal. Then according to Wollf's law of transformation the internal structure of the affected bones begins to change to accommodate itself to the new conditions of weight and strain induced by the change in action and attitude; and to this rearrangement of the internal structure, the external shape of the bones must conform in a gradual growth toward the normal contour.

[1] Beiträge zur Klin. Chir., Bd. 14, H. 1.
[2] Archiv f. Klin. Chir., Bd. 50, S. 130.

On this theory, it is easily explained how the natural outdoor life of the country has long been celebrated as an effective treatment for this class of deformity. But it by no means follows that deformity is always outgrown, even under favorable conditions. Improper attitudes, that favor and cause deformity, are often observed among those who are free from weakness and disability and from the influences of unfavorable surroundings; and such attitudes are of course more likely to persist in those who were once obliged to assume them because of weakness and deformity. Again, the weakness of structure or function may be an inherited peculiarity, or it may be induced by disease or by improper surroundings, influences that may continue for many years and thus serve to check the natural tendency toward cure.

FIG. 284.



Extreme deformities, the result of infantile rhachitis. The leg forms practically a right angle with the thigh. (See Fig. 288.)

The observations on the outgrowth of deformity have been confined, as a rule, to the period of childhood, and most often they have been made with reference to the more serious grades of distortion, which are the direct result of rhachitis.

It must be borne in mind, however, that the true significance of these deformities in the adult must be judged from the æsthetic, rather than from the medical point of view, and although the extreme degrees of bow leg and knock knee are relatively rare yet in the minor grade both deformities are very common in adult males and in all probability in adult females also.

In 1887 the writer[1] noted among 2,000 adult males observed on the streets of Boston, 400 cases of bow leg and 32 cases of knock knee. One may assume then that the legs of about one adult male in five deviate more or less from the line of symmetry, a conclusion that has been confirmed by many subsequent observations. It may be admitted that a certain number of the distortions under consideration are acquired during adolescence, but it is probable that the greater num-

[1] N. Y. Med. Rec., July 30, 1887.

ber of those that may be noted in walkers upon the streets represent the incomplete outgrowth of a deformity of childhood.

The statement is often made that these distortions of the legs are common in childhood but rare in adult life. Just what the proportion may be in childhood it is impossible to say, but it is not likely to be greater than one in five. One must conclude that statistics, on which such statements are based, have been made up from the records of hospitals where it is extremely uncommon for an adult to apply for the treatment of bow leg, to which he has become accustomed since childhood, unless the deformity is very extreme or is attended by pain.

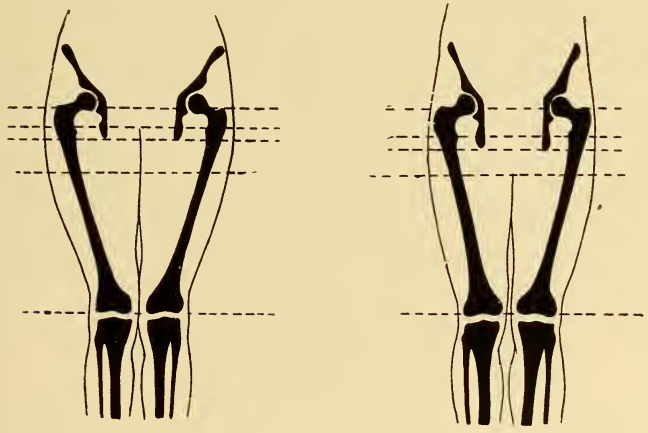
Granting that the power of nature is quite sufficient to modify, or to cure even the more extreme distortions of childhood, still it would seem that this natural force is often ineffective in completing the cure. Therefore in doubtful cases, at least, one should lend assistance in that class of patients likely to appreciate the advantage of symmetry over slight deformity, even though it be unattended by discomfort or disability.

Genu Valgum.

Synonyms.—Knock Knee, In Knee.

In the erect posture the thighs, whose upper extremities are separated by the pelvis and by the projecting femoral necks, incline slightly inward to the knees, forming an angle at the knee, opening outward,

FIG. 285. FIG. 286.



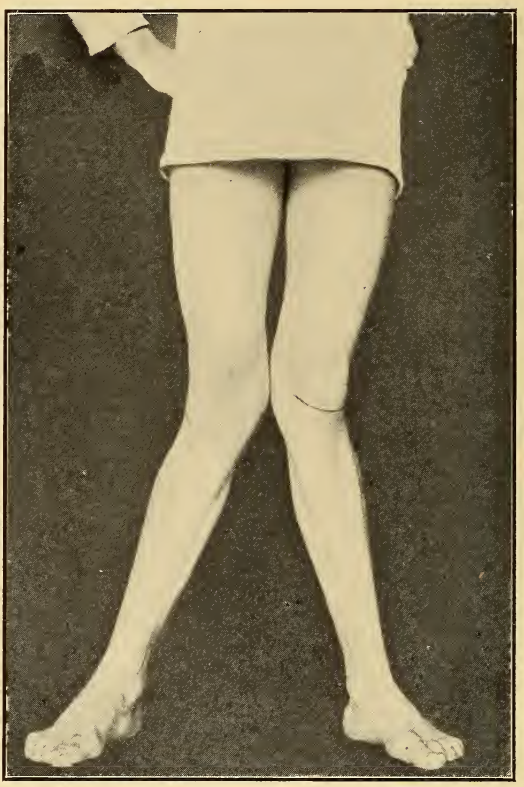
Female. Male.

The normal inclination of the femora. (PFEIFFER.)

of about 172 degrees. This angle varies with the breadth of the pelvis, and it is therefore less in adult females than in males. (Figs. 285, 286.) The internal condyle of the femur is slightly longer than the external, thus the inclination of the femur is compensated and the plane of the knee joint is horizontal.

When the inward projection of the knees is increased to a noticeable degree the tibiæ are no longer perpendicular, their upper extremities incline inward so that in the erect posture the feet are separated when the knees are in contact. (Fig. 287.) In the slighter grades of knock knee, which are due in great degree to laxity of the ligaments, the deformity is apparent only when the weight of the body is borne, but in more marked cases, although the distortion is increased by the weight of the body, it can not be overcome when this is removed because it depends upon actual changes in the shape of the bones themselves.

FIG. 287.



Adolescent knock knees. Deformity most marked in the tibiæ. (See Fig. 290.)

As has been stated, the normal inward inclination of the femur is compensated by the greater length of the internal condyle, and in the deformity of knock knee the plane of the knee joint is still preserved by an apparent elongation of the inner condyle. Formerly it was supposed that there was an actual over-growth of this part of the epiphysis, which caused the deformity, but the observations of Mickulicz and Macewen have shown that this apparent lengthening is in reality due, in great part, to a deformity of the lower extremity of the shaft of the

femur, which is so bent that the epiphyseal line has an increased obliquity. And the hypothesis that bone grows more rapidly when relieved from weight and strain has been disproved by Wollf, who has shown that changes in the bones are the result of accommodation to altered function and attitude. (See page 190.) The deformity is not limited to the femur; in most instances there is a similar, although usually slighter, irregularity in the epiphyseal line of the upper extremity of the tibia, the shaft being so bent that when it is placed in the perpen-

FIG. 288.

Skiagram of Fig. 284 showing the deformity to be due to distortions of the diaphyses of the bones while the epiphyses are practically normal.

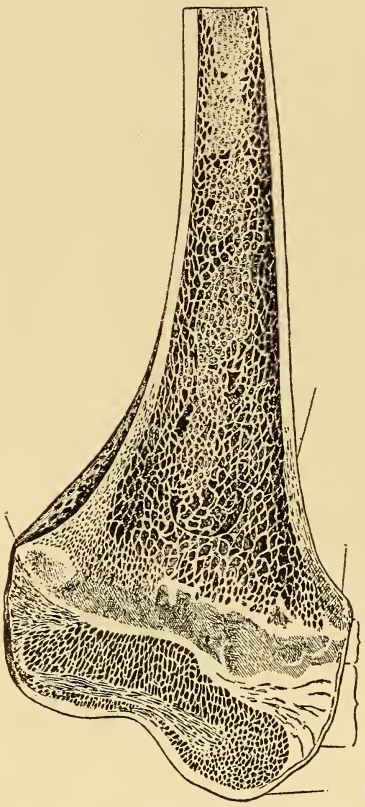
dicular position its internal condylar surface is higher than the external. (Fig. 288.)

CHANGED RELATION OF THE FEMUR AND TIBIA.—In addition to the direct deformities of the bones there is a change in the relation of the femur to the tibia. The former is rotated inward and the latter is rotated outward. In some instances there is also a certain degree of over-extension at the knee. This is more often observed in the adolescent type in which there is laxity of the ligaments, but in the ordinary form of rhachitic knock knee in childhood, the habitual attitude is one of slight flexion at the knees and in extreme cases there may

be actual limitation of the range of extension at the knee, and at the hip as well.

The Accommodative Attitude.—When the limb is fully extended, the deformity is most marked because the shortened ligaments and tissues on the outer aspect of the joint become tense, and because the outward rotation of the tibia is increased. As the leg is flexed the deformity lessens, and in the attitude of complete flexion it disappears. (Fig. 290.) This is explained by the fact that the posterior surface of the condyles is not affected by the deformity of the shaft, while the relaxation of the ligaments and the outward rotation of the femora allow the tibiæ to become parallel with one another. This explains the habitual attitude of slight flexion which is so often assumed by patients who thus unconsciously accommodate themselves to the deformity.

Fig. 289.



Deformity of the femur in genu valgum. (Mickulicz.)

Secondary Deformities. — The outward inclination of the leg throws more weight upon the inner border of the foot and tends to depress it into the attitude of valgus. Thus knock knee in weak children is often accompanied by flat foot, but in the more extreme grades of deformity the efforts of the patient to compensate for the abnormal separation of the feet may result in habitual supination, in fact, confirmed and extreme knock knee is often accompanied by a slight degree of varus that becomes very evident after the correction of the deformity by operation. Even in the mildest type of knock knee, this compensatory and conservative effort of nature shown by the so-called pigeon-toed walk, may be the first symptom that attracts attention.

Gait.—The gait of the patient with well-marked genu valgum is peculiarly awkward and shambling. The knees "interfere" and must be assisted, as it were, in the effort to pass one another in walking. In the slighter cases, the thigh is abducted and rotated outward at the moment of passing its fellow, the movement being then reversed as it, in its turn, supports the weight; but in the more severe type this voluntary effort of the muscles of the leg is not sufficient, and in addition, the body is swayed from side to side and the legs are alternately swung outward and lifted around one another.

The deformity and the effects of the deformity on the gait and attitude are the most important symptoms, as of other distortions of similar origin. The patient is, as a rule, easily fatigued, and pain during the progressive stage, referred to the inner side of the knee where the ligaments are subjected to continuous strain, is a common symptom, particularly in the adolescent type of genu valgum.

Unilateral Knock Knee.—This description refers particularly to the cases in which the deformity is bilateral. Not infrequently it is unilateral, the leg being so shortened by the distortion that a well-marked limp replaces the swaying gait. The pelvis is tilted toward the short

Fig. 290.

Adolescent knock knee, showing the disappearance of the deformity when legs are flexed. (See Fig. 287.)

leg, while the body is inclined in the opposite direction, so that in cases of long standing, a permanent curvature of the lumbar spine may be present.

Knock Knee Combined with Bow Leg and with General Rhachitic Distortions.—Occasionally the unilateral knock knee may be accompanied by an outward bowing of its fellow; and in the marked distortions of the lower extremity, that are the result of rhachitis, the bones may be twisted and bent in various directions, although the outward expression of the deformity may be genu valgum. For example, the femora may be bent forward and outward above, and inward and backward below, while the tibiæ may be bent inward above, and outward and forward below.

In other instances, especially in the slighter rhachitic deformities, an outward bowing of the tibiæ may accompany a slight degree of knock knees, so that it is difficult to classify the deformity.

In the more extreme deformities of the rhachitic type, the shape as well as the contour of the bones is modified, for example, the internal border of the tibia may become very prominent at its upper extremity, and may project beneath the skin like an exostosis. (Fig. 291.) A change in the contour of the fibula accompanies and corresponds to that of the tibia although it is, as a rule, much less pronounced. As

Fig. 291.

Knock knee and bow leg.

has been stated, the internal structure or architecture of the affected bones is changed to accommodate the new static conditions, and according to Wollf the internal change precedes the external deformity.

Pathology.—In knock knee due directly to rhachitis the changes in the bones and in the epiphyseal cartilages are characteristic of that affection, but in the milder grades of deformity, aside from the change in the contour of the bones, the transformation of the internal structure,

and in some instances slight thickening or irregularity of the epiphyseal cartilage, there is little noteworthy change from the normal. (Fig. 289.) The tissues on the internal aspect of the joint are relaxed, those on the outer side, the lateral ligaments, the capsule and the biceps muscle, are contracted and resist the reduction of the deformity. In the interior of the joint slight changes in the articulating surfaces of the bones, and evidences of chronic irritation of the synovial membrane have been described.

Measurements.—There are various methods of measuring the deformity. One of the simplest and most practical is to trace the outlines on paper, while the child is seated with the legs fully extended, the knees being sufficiently separated to allow the pencil to pass between them. The increase of the deformity, dependent upon the laxity of the ligaments and upon the outward rotation of the tibiæ, may be estimated by measuring the distance between the two internal malleoli when the patient stands, the knees being slightly separated as before and comparing this measurement with that between the similar points in the tracing. In the early stage of progressive knock knee, particularly in the type not caused directly by rhachitis, laxity of ligaments and the habitual assumption of the attitude of rest, will account for the deformity, which the patient may be able to overcome, in great degree at least, by voluntary effort. This voluntary control of the deformity is very suggestive, as indicating certain factors in its etiology and the principles that should be followed in its treatment.

Treatment.—The treatment of the deformity under consideration may be classified as: Expectant, mechanical, and operative.

Expectant treatment should not be expectant in the sense that nothing is to be done to correct the deformity, but expectant in that more positive treatment by braces or by operation is delayed, or avoided if it prove to be unnecessary.

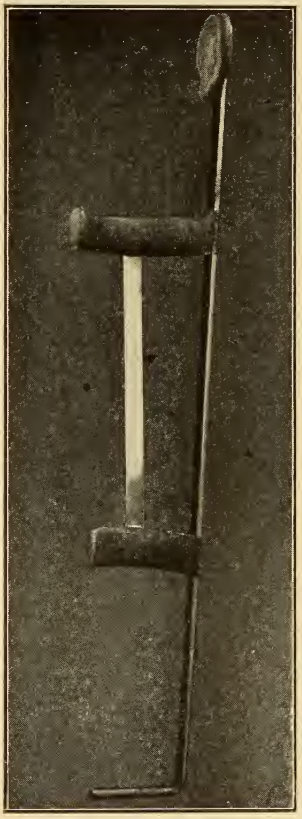
During the expectant period the cause of the deformity, if it is constitutional, should receive proper dietetic or medicinal treatment as already described in the chapter on rhachitis. And, if possible, the direct exciting causes of the deformity must be removed, that is to say, the improper attitudes or, in the adolescent, the predisposing occupations should be discontinued. General massage of the limbs may be employed with advantage; in older children special exercises may be practiced, and in all cases, whether braces are used or not, direct manipulation of the distorted limbs is of the first importance.

Manipulation.—In the slight degrees of deformity, more especially of that type in which the distortion appears to be due to simple weakness rather than to rhachitis, the expectant treatment may be tested. The legs should be vigorously massaged at morning and night, and forcibly straightened. The latter procedure is conducted as follows: the patient is seated in a chair, the limb being fully extended so that the deformity is made as extreme as possible. One hand then clasps the knee, the palm lying against its inner aspect; with the other, the calf is grasped firmly and the leg is then gently straightened over

the fulcrum formed by the palm of the hand, and is held in the corrected position for a moment. This manipulation should be continued with gradually increasing force, although not to the extent of causing actual pain, for ten minutes, at least twice in the day and oftener if possible.

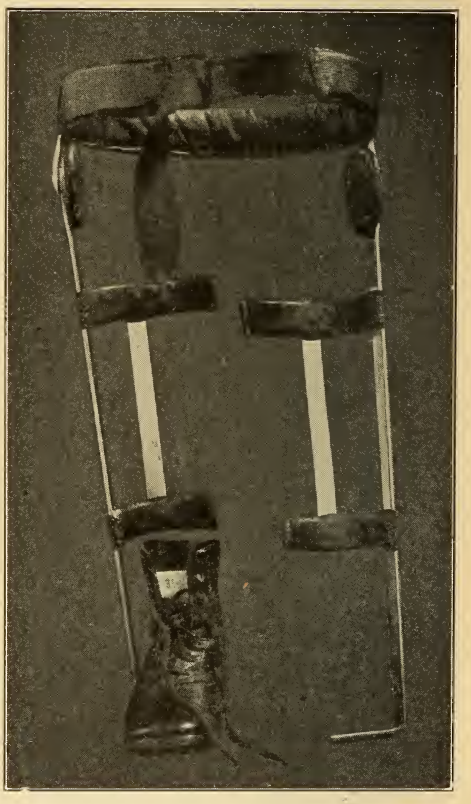
Posture and Exercise.—It has been stated that genu valgum is often accompanied, especially in the rhachitic cases, by flat foot, while in another type the inversion of the feet, or in the more severe cases the actual fixed attitude of varus, indicates the effort of nature to with-

Fig. 292.



The Thomas knock knee brace.

Fig. 293.



Thomas knock knee braces with pelvic band.

stand and to compensate for the deformity at the knee. This serves as an indication for making the soles of the shoes thicker on the inner side as in the treatment of flat foot, in order to throw the strain upon the outer border of the foot. The patient should be instructed to walk with the feet parallel with one another, and for older children the tip-toe exercises, in which the body is raised upon the toes as many times as the strength permits, or games or exercises in which the legs are extended should be encouraged. Such exercises are often efficacious

in the early stage of adolescent knock knee, for as has been mentioned, genu valgum is an exaggeration of the attitude of rest, therefore its progress should be checked by the assumption of the attitudes proper to activity. A careful record of the deformity should be kept during this tentative treatment and if it improves somewhat, one is justified in delaying the more radical measures. This question may be decided, as a rule, in three months, if instructions are faithfully followed.

FIG. 294.

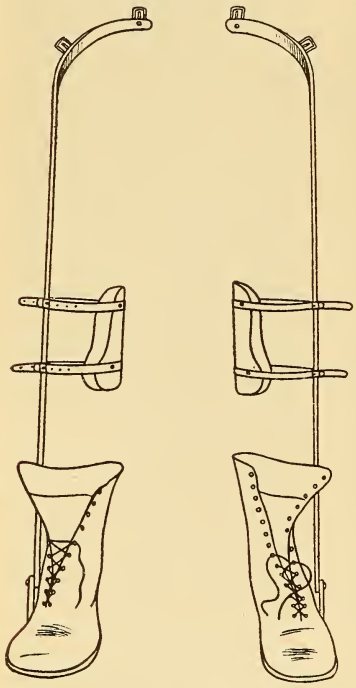
Modified Thomas knock knee braces applied.

Treatment by Braces.—The most efficient brace in the treatment of genu valgum is the simple straight steel bar or splint extending from the trochanter to the heel of the shoe, without joint at the knee. The greater efficacy of the rigid bar as compared with the jointed brace is explained by the fact that the rectifying force acts constantly when the joint is fixed, and because, in many instances, the patient habitually flexes the knees so that direct pressure cannot be made upon the deformity by a brace that allows this attitude.

The Thomas Brace.—The simplest and cheapest brace is that of Thomas, which consists of a light steel bar provided with a pad at its upper end for pressure against the trochanter, while the lower rounded extremity is turned inward at a right angle, to pass through the heel of the shoe. The knee is fixed by a posterior bar attached to a thigh and calf band, as illustrated in the figure. When the brace is applied the knee is drawn backward and outward and is attached firmly to the brace by a roller bandage. (Fig. 292.)

In the more extreme cases in which the knees and thighs are habitually flexed, the addition of a pelvic band attached to the uprights by a free joint at the hips, adds to the comfort and efficiency of the apparatus, as the attitude of outward or inward rotation can be regulated by twisting the uprights slightly. Or the pelvic band may be divided and attached by means of straps on the front and back. The uprights may be bent somewhat inward at first, and as the legs become straighter they are straightened and finally bent slightly outward to allow for the over-correction of the deformity. (Fig. 294.) Twice a day the braces should be removed to allow for massage, manipulation and for voluntary exercises of the legs. In most cases the braces are not employed at night, although the rectification of the deformity may be hastened by their constant use.

Fig. 295.



Long braces for genu valgum. (Bradford and Lovett.)

If the deformity is unilateral so that a brace is required for one leg only, the other shoe should be raised by a cork sole about three quarters of an inch in thickness to make walking easier. Children soon become accustomed to the braces and walk easily in spite of the absence of joints at the knees.

Another simple and efficient brace is that used at the Children's Hospital at Boston. (Fig. 295.) The upper part of the brace is turned backward and upward to lie against the buttock, and the feet can be rotated in or out by lengthening or shortening straps passing before and behind the body. Braces jointed at the knee are sometimes employed, but they are, as a rule, ineffective except in the slighter cases in which the deformity depends upon laxity of ligaments rather than distortion of bone.

Duration of Treatment by Braces.—The duration of the brace treatment depends, of course, upon the degree of deformity, the

age of the child and upon the efficiency of the apparatus. From six months to one year of treatment by this means is usually required. The cure is assured by the gradual adaptation of the parts to the new static conditions. The contracted tissues of the outer aspect of the joint become lengthened; the lax ligaments on the inner side contract; the internal structure of the condyles and of the adjoining diaphysis is gradually transformed and at the external contour of the bone becomes correspondingly straighter. When the braces are discarded, attention should be paid to the attitudes, and the exercises that have been mentioned should be continued in order that relapse may be prevented.

The Plaster Bandage.—When the bones are yielding, as in the deformity due directly to rhachitis in young children, it may be corrected rapidly by the repeated applications of plaster bandages, the leg being straightened as far as possible without causing discomfort, at each sitting. This method is rarely employed except in dispensary practice.

Operative Treatment.—Immediate correction of the deformity, when it is at all marked, is as a rule indicated after the age of four or five years. It is perhaps needless to remark that the necessity for operation implies neglect of proper preventive treatment or the failure of the manipulative and mechanical methods because of their improper application. While it is possible to correct deformity of the bone by mechanical treatment in cases far beyond this limit of age, yet the time required and the discomforts of the treatment exclude it in all but very exceptional cases.

Osteotomy.—At the Hospital for Ruptured and Crippled, osteotomy is invariably performed in the treatment of genu valgum by means of the small Vance osteotome, the so-called "subcutaneous osteotomy." (Fig. 262.)

The limb having been prepared in the usual manner is semiflexed and the inner surface of the knee is placed on a firm sand bag. With the fingers the femur is firmly grasped just above the condyles so that its size and position may be accurately determined, and the sharp osteotome about the size of a lead pencil is forced with its cutting edge parallel to the axis of the thigh down to the bone, at a point about one and a-half inches above the external tuberosity. While it is held firmly in position against the bone it is turned to the transverse direction and is then driven through the cortex. When it enters the medullary canal, as is made evident by the lessened resistance, it is partly withdrawn and moved slightly to one side and the other and driven through the cortical substance until by gentle force the bone may be fractured. The osteotome is then withdrawn, the minute wound is covered with a pad of dry gauze, or if the oozing is profuse it may be closed with a catgut suture. The deformity is then slightly over-corrected and a plaster spica bandage is applied. If the deformity is double both limbs are operated upon at the same sitting.

The plaster bandage is continued for from four to six weeks and it is then usually supplemented by a brace which may be worn with ad-

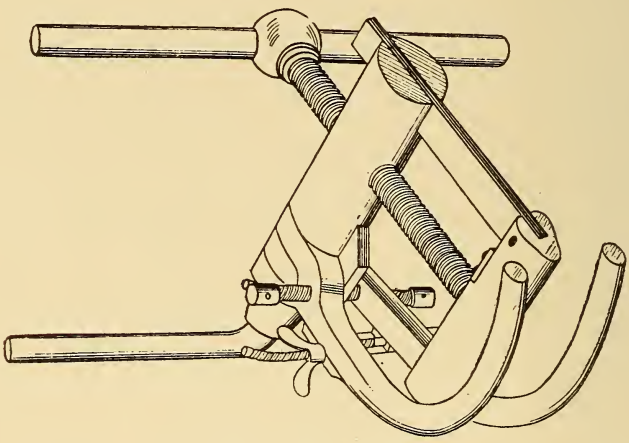
vantage for several months, because of the laxity of the ligaments of the knee joint which is usually present in extreme deformity of rhachitic origin. In less marked cases, the support is unnecessary. Massage and exercises during the stage of recovery should be employed if possible.

In some instances the osteotomy of the femur may be performed from the inner side at the same level more conveniently, especially if the deformity is extreme.

Incomplete osteotomy and fracture in the manner described has been employed at the Hospital for Ruptured and Crippled in a very large number of cases without a single unfavorable result. The discomfort is insignificant and confinement to the bed after the third day is unnecessary.

Cuneiform Osteotomy.—In the more extreme cases of general rhachitic deformity of the lower extremity in which the tibia is implicated, it is sometimes necessary to remove a cuneiform section of bone from the inner side of the tibia just below the epiphysis in order to straighten the leg completely. In such cases it is better to perform

Fig. 296.



The Grattan osteoclast.

the second operation at a later time in order that the effect of the femoral osteotomy may be observed. In exceptional cases the deformity may be practically confined to the tibia; in such instances it should be corrected by a primary cuneiform osteotomy.

Osteoclasis.—Osteoclasis, by means of the Grattan osteoclast, is an effective operation. With this instrument the bone may be broken above the condyles at the desired point, but the force required is considerable and it would seem that there might be danger of separating the epiphysis or otherwise injuring the joint, a danger that may be avoided by osteotomy.

The adolescent type of genu valgum is not often extreme. As a rule,

the deformity of the bone is of comparatively short duration, and it is accompanied by considerable laxity of ligaments. In the more chronic cases the osteotomy above the condyles may be performed in the manner described, but in Berlin and Vienna where the deformity is more common than in New York, other procedures are often employed.

Wollf's Treatment.—One method is that of Wollf, who by means of the "Etappen Verband" gradually corrects the deformity.

The patient is anæsthetized and the limb having been carefully protected with cotton, particularly so about the malleoli, the patella and the inner condyle, is enveloped in a firm plaster bandage reaching from the malleoli to the pubes. When the plaster begins to harden one assistant steadies the pelvis, another holds the inner condyle, while the operator draws the leg inward with moderate but persistent force against the fulcrum formed by the hand of the second assistant and holds it firmly in the partly corrected position until the bandage is firm. About three days later a wedge-shaped section of the bandage about one inch in width is removed from the part that covers the inner half of the knee, the outer half of the bandage being simply divided. The leg is then forced inward until the two sections are again brought into contact. The position is retained by an additional plaster bandage about the weakened part. This procedure is repeated at intervals until the leg is completely straightened, a result that is often accomplished in two weeks. No anæsthetic is required for the secondary corrections. When the deformity has been corrected the patient is allowed to walk about, and for convenience the plaster bandage is divided into a thigh and leg part which are attached by lateral joints incorporated in its substance so that motion is allowed. This apparatus must be worn for several months and is of course to be supplemented by massage and exercises.

Lorenz's Operation.—Another means of correction of deformity without open operation is that employed by Lorenz, what he calls "Intraarticulare modelirerende redressement." In this operation the deformity is reduced under anæsthesia at one sitting by the gradual application of force by means of the Lorenz osteoclast. The reduction depends partly upon the stretching of the external ligaments and partly upon the actual bending of the diaphysis of the bone, as in the Wollf method.

When the leg has been straightened, or somewhat over-corrected even, a long plaster bandage is applied which is worn for six weeks and is then replaced by a jointed walking brace to be worn for about a year. The operation is not attended by severe pain and the patient is usually allowed to walk about in a few days.

Genu Varum.

Synonym.—Bow Leg.

The term bow legs includes, in its popular sense, all the distortions that cause a separation of the knees when the ankles are in contact with one another. But, strictly speaking, genu varum is the reverse of genu

valgum, that is, the cause of the distortion is at or near the knee joint, while bow leg, as the name implies, is a simple bowing of the tibia and fibula, as a rule near the ankle joint. (Fig. 303.) In true genu varum a line dropped from the head of the femur falls inside the knee (Fig. 297), the inner condyle of the femur and the inner tuberosity of the tibia bear the greater part of the weight, the outer condyle is on the same level or somewhat lower than the internal and the outer tuberosity of the tibia may be somewhat higher than the internal. The femur is abducted and rotated outward, the tibia is rotated inward. These changes, it will be noted, are the reverse of those found in genu valgum. As has been stated, the deformity of genu valgum disappears when the legs are flexed, and in genu varum if the legs are flexed and the knees are placed in contact with one another the malleoli may be actually separated, simulating the deformity of knock knee. (Fig. 298.) This is

Fig. 297.

The genu varum type of bow legs, showing the outward rotation of the femora.

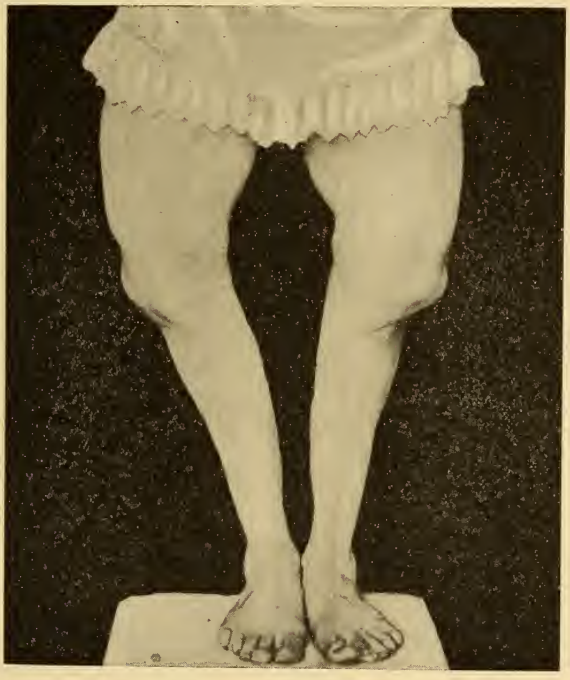
Fig. 298.

The same patient, showing the separation of the malleoli when the knees are in contact.

explained by the inward rotation of the femora, necessitated by placing the knees in contact with one another.

In genu varum the distortion of the bones is not as strictly confined to the neighborhood of the knee joint as in genu valgum, and in simple bow leg there is almost always a certain amount of distortion at the knee, dependent, in part, upon laxity of the ligaments. It is proper therefore to use the two terms synonymously, although one must distinguish a decided difference between the genu-varum type in which the deformity is greatest at the knee, and which is accompanied as a rule by marked laxity of the ligaments (Fig. 299), and the bow-leg

FIG. 299.



Genu varum of rhachitic origin in an adult. Treated successfully by osteotomy.

type in which the deformity may be strictly confined to the lower third of the leg. (Fig. 303.)

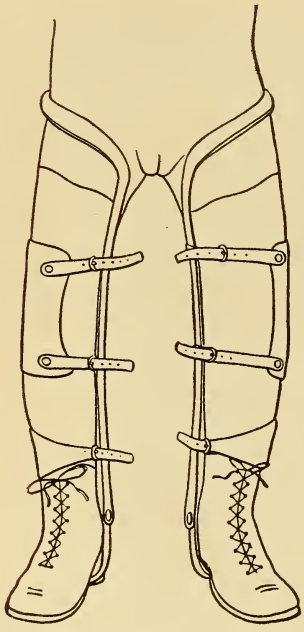
Symptoms.—As was said of genu valgum, the deformity is the principal symptom. The gait is somewhat rolling because each foot must describe a part of the arc of a circle before reaching the ground; and because of the inward rotation of the tibiæ or because of the inward spiral twist of the bone that is sometimes present, patients often toe in, in walking.

Except in extreme cases the weakness and awkwardness, characteristic of genu valgum, are absent. This may be explained by the fact

that the relation of the bones is such that the general attitude is one of activity, the weight falling on the outer side of the feet, thus flat foot is uncommon as an accompaniment of bow leg, except in the early or rhachitic type.

Measurements.—The full effect of the deformity appears only when the weight of the body is borne, but for practical purposes the tracing of the extended legs is the best method of recording the fixed deformity. In true genu varum the deformity is greatest at the knee and in the distortion the apposed surfaces of the femur and of the tibia participate.

Fig. 300.



Long braces for genu varum. (Bradford and Lovett.)

In simple bow leg the deformity may be confined to the tibia, which, in addition to the outward bowing, may be twisted inward somewhat upon its long axis.

Genu varum may be unilateral or it may be combined with genu valgum of its fellow (Fig. 291), and occasionally slight knock knee and slight bow leg may be present in the same limb.

Treatment. Expectant Treatment.—The slighter cases of bow leg in early childhood may be treated by manipulation. The leg, grasped firmly at the ankle and at the knee, is straightened with a certain amount of force, over and over again. Gradual correction by this means may be hastened by making the sole of the shoe slightly thicker on the outer border. This aids, also, in correcting the secondary pigeon toe, but if the foot is weak, as it usually is in rhachitic cases, this method should not be employed, as it might induce flat foot.

Treatment by Braces.—If the deformity is more extreme, or if improvement does not follow expectant treatment, apparatus should be employed. If the distortion is confined to the lower third of the tibia, a Knight brace may be used. It consists of two uprights attached to a foot plate, the inner bar is provided with a pad at its upper end for pressure on the internal condyle of the femur. The outer bar reaches to the head of the fibula and the two are joined by a calf band. When applied the leg is drawn toward the inner upright by means of a lacing, which passes about it within the outer bar. When the lacing is made fast, the outer bar is bent toward the leg and thus it aids somewhat in supporting it in an improved position. The foot plate may be dispensed with and the brace may be attached to the shoe and even the outer bar may be removed, leaving only the upright, which is held in position by the lacing. The apparatus, then, has the appearance of a

gaiter and has the advantage of being inconspicuous, although somewhat less effective than the Knight brace. By this apparatus, combined with vigorous manipulation, the deformity may be corrected, in young children, in about six months.

If the outward bowing of the knee is marked, another form of apparatus will be necessary, and its effectiveness will be much increased if there is no joint at the knee. The outer bar, shaped to the contour of the leg, is attached above to a pelvic band and below to a foot plate, as is the short brace. An inner straight bar extends to the upper third of the thigh and is attached to the outer bar by a thigh band. This inner upright is provided with a lacing of leather or canvas, similar to that of the short brace, which surrounds the knee and upper part of the leg, and thus draws it toward an improved position. The outer bar is then bent slightly inward and serves as an additional support. Another form of apparatus consists of a single upright, attached to the shoe and extending upward as high as possible on the inner aspect of the thigh. At its upper extremity a pressure pad is placed and the knee is drawn toward it by means of straps or bandages.

An improved brace of this kind is that in use at the Boston Children's Hospital, in which the upper part of the upright is curved upward and outward just below the groin, to a point on a level with, and behind, the trochanter, and is attached to its fellow by means of a strap passing across the buttocks so that the feet may be somewhat rotated outward if necessary. (Fig. 300.)

Operative Treatment.—In children more than five years of age, and in cases of the more extreme type at an earlier age, or when the opportunity for mechanical treatment is lacking, immediate correction of the deformity is indicated. Either osteoclasis or osteotomy may be employed, and in some instances manual force is sufficient for the correction of the deformity. There is but little choice between the methods. Osteoclasis is somewhat safer possibly, and is to be preferred for the younger patients who may be treated as out-patients.

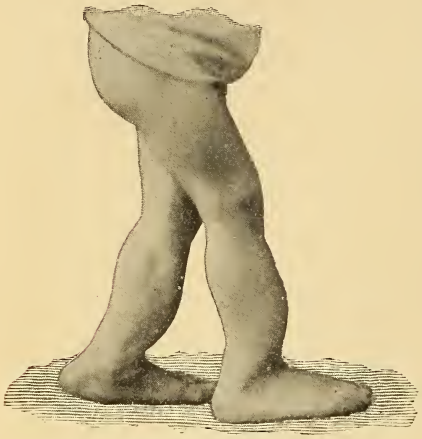
At the Hospital for Ruptured and Crippled, osteotomy is almost invariably performed. The small osteotome is inserted on the inner aspect of the tibia at the point of greatest deformity, and when the bone has been sufficiently weakened, the fracture is completed by manual force. The fibula may be broken at the same time, or, as is usually the case, it may be simply bent outward. The deformity is corrected or slightly over-corrected and a well-fitting plaster bandage, including the foot and extending to the trochanter, is applied.

The patient usually remains in bed for a few days, he is then dressed and if he so desires is allowed to stand. Almost no pain or discomfort follows the operation and in fact, in properly selected cases, it is not only free from danger, but it has a very decided advantage over the simple mechanical treatment. If the child is in good condition, and if the deformity is slightly over-corrected at the time of operation, apparatus will not be required in the after-treatment; but in many instances some form of support is indicated, usually because slight

deformity, due to laxity of ligaments or to deformity of the femur, appears when the weight of the body falls upon the legs.

It has been stated that the deformity of bow leg depends in part upon a deformity of the femur as well as of the tibia. As a rule, the correction of the greater deformity of the tibia will be sufficient, but in more extreme cases a secondary osteotomy above the condyles will be necessary. This may be performed simultaneously with that on the tibia, but it is better to defer it until the effect of the primary operation has been observed.

Fig. 301.



Anterior bow legs.

Anterior Bow Leg.

Synonym. — Anterior Curvature of the Tibia.

Both bow legs and knock knees are often seen in children who present no signs of general rhachitis, but anterior bowing of the legs is almost always combined with general rhachitic distortions of the lower extremity, most often with knock knees; these in turn are caused by marked distortion of the femora which may be bent forward and out-

Fig. 302.

Long anterior curvature of the tibia and flat foot.

ward above, and inward at their lower extremities, "corkscrew deformity." In anterior bow legs the tibiæ are usually flattened from side to side, curved inward or outward and bent forward, the projecting crests presenting sharply beneath the skin.

Symptoms.—The effect of the anterior bowing is to throw the weight forward upon the foot, thus the heels appear abnormally long and prominent, and the patient seems to sink forward at each step. (Fig. 303.) The knees are usually somewhat flexed, partly as the effect of knock knee with which the deformity is usually combined, and the feet are, as a rule, flat. As has been stated, anterior bowing is almost never seen as an independent deformity unless it is a relic of the more general distortion which has been "outgrown."

Fig. 303.

Rhachitic anterior bow legs.

Treatment.—Anterior curvature of the tibia must, as a rule, be treated by operation. After complete division of the tibia and fibula, the deformity may be overcome by forcing the bones directly backward. In certain instances tenotomy of the tendo Achillis may be required. Cuneiform osteotomy of the tibia permits more perfect correction, but the final result is equally good after simple osteotomy.

General Rhachitic Distortions.

General rhachitic distortions have been mentioned in connection with knock knee, and with anterior bow leg. A more extended description is hardly necessary. The deformities are usually of the knock-knee type, and they may be treated on the same general plan that has been outlined in the description of the less extreme distortions.

CHAPTER XVI.

DEFORMITIES OF THE UPPER EXTREMITY.

Congenital Dislocation of the Shoulder.

This may occur in two forms, one in which there is actual misplacement before birth, and the other in which a dislocation is caused by violence at birth. In either case the displacement is almost always backward upon the dorsum of the scapula (subspinous). Thus the arm is abducted and rotated inward and the head of the displaced bone may be felt in its abnormal position. Cases of congenital displacement in other directions are recorded, but these are so unusual as to be of little practical importance.[1]

True primary displacement of either variety is rare. Many of the reported cases were apparently subluxations secondary to the relaxation of the capsule of the joint and to the muscular atrophy caused by anterior poliomyelitis, or more often to the habitual malposition due to obstetrical paralysis. (Fig. 305.)

Treatment.—The only treatment of a dislocation is replacement of the displaced bone, if it be possible. If the displacement were discovered in infancy, it might be possible to reduce it by manipulation, especially if it were of traumatic origin. As a rule, however, the cases are not seen until later childhood when the accommodative changes are so great as to necessitate the open operation.

Phelps, of New York, has reported several cases of congenital dislocation of the shoulder, caused apparently by injury at birth, as most of them were accompanied by paralysis. In the first case (a boy eight years of age) the joint was opened by a posterior incision along the border of the deltoid muscle. The head of the scapula was found to be atrophied and the posterior margin of the glenoid cavity broken away. This, together with the contraction of the tissues on the anterior aspect of the joint, made it necessary to cut away a part of the head of the bone in order to replace it. The secondary articulating surface on the scapula was excised and the redundant capsule was removed. The immediate result of the operation was very favorable. Phelps states that he has operated on two similar cases, but a final report of the results has not been presented.[2]

It would seem, however, that as in a posterior displacement the contracted tissues must be those in front of the joint, an anterior rather than a posterior incision, would be preferable. In any event prolonged

[1] Scudder, Am. Jour. Med. Sci., February, 1898.
[2] Trans. Am. Orth. Ass'n, Vol. VIII.

forcible manual stretching of the contracted parts in the manner described in the treatment of congenital dislocation of the hip should precede the opening of the joint. By this means the writer has reduced the displacement easily in two cases in early childhood.

Obstetrical Paralysis.

Partial or complete paralysis of the muscles of the arm may be a result of difficult or protracted labor. This may be due to direct injury of the brachial plexus by the forceps, but most often it is caused by traction on the body or the head and by violent twists of the neck during delivery. The muscles most often paralyzed are those supplied principally by the fifth and sixth cervical roots of the plexus, the deltoid, the biceps, and the supinators of the forearm.[1] Thus in most instances the arm hangs in an attitude of slight abduction and exaggerated pronation. (Fig. 304.) If the attitude is allowed to persist and if the paralysis is permanent, the head of the humerus rotated backward beneath the atrophied deltoid muscle and held in the abnormal attitude by accommodative changes in the capsule and surrounding parts, simulates very closely in later years the true congenital dislocation of the shoulder. (Fig. 305.)

Fig. 304.

Obstetrical paralysis. Characteristic attitude.

Whether cases reported as congenital displacement of the shoulder are secondary to paralysis or not, it is evident that all cases of obstetrical paralysis should be carefully examined with regard to a complicating dislocation, and that secondary deformity caused by paralysis should be prevented.

Treatment.—During the first month after birth, the shoulder of the paralyzed arm is often somewhat swollen and motion may cause pain. In such cases rest is indicated. The arm should be placed against the side, and the hand, with the fingers extended, should be supported on the chest beneath the clothing. When the primary sensitiveness has subsided, each of the joints of the extremity should be moved systematically to the limits of the normal range of motion several times in the day. Particular care should be exercised in supinating the forearm to its full limit and extending the wrist and

[1] Thomas, Johns Hopkins Hosp. Bulletin, Nov., 1900.

fingers, if they are involved in the paralysis. The muscles should be massaged and the arm should be supported by a sling, or otherwise, in proper position. Recovery may be complete, although it is often delayed for many months. As a rule, traces of the injury are evident in atrophy of certain muscles, particularly of the deltoid, and a certain weakness of the arm persists, even though no paralysis remains.

In many instances recovery is but partial, the arm is weak, certain muscles are paralyzed, and there is much restriction of movement at the shoulder. The growth of the member is retarded and the attitude simulates that of posterior dislocation, as has been stated. Even in such cases massage and exercises and training will often improve the functional ability of the disabled part.

FIG. 305.

Obstetrical paralysis in adolescence.

Recurrent Dislocation of the Shoulder.

Recurrent dislocation of the shoulder is usually a sequel to traumatic dislocation. The cause of the instability is usually laxity of the capsular ligament and weakness of the supporting muscles, the result, it may be, of too early use of the arm after the accident. In rare instances greater derangement of the joint, caused by fracture of one or other of the articulating surfaces, rupture or displacement of ligaments or muscles, or permanent paralysis of the deltoid muscle may be present.

The displacement, which may be partial or complete, recurs at intervals and is a very serious disability.

Treatment.—If the patient is seen immediately after a displacement and if the dislocation has recurred but a few times and at long intervals, it may be inferred that the disability is the result of simple laxity of the capsule and of muscular weakness. In such cases a period of fixation followed by massage and exercise of the atrophied muscles may result in cure. The patient should be carefully questioned as to the particular movements of the arm that are likely to cause the displacement,

which is, as a rule, forward beneath the coracoid process. Most often elevation and abduction seem to be the exciting causes, and these motions should be restrained. A simple and often an effective means of treatment, is the application of a shoulder cap of canvas that fits closely about the shoulder and upper arm. This is held in place by bands crossing the body and buckled beneath the other arm; from the lower border of the cap one or more bands pass downward and are attached with the braces to the trousers, so that elevation of the arm is restrained, before the point of instability is reached.

Operative Treatment.—If these milder measures are ineffective an operation to reduce the size of the lax capsule may be performed according to the method employed by Burrell. The arm being slightly abducted, an incision is made from the coracoid process downward and outward along the line of the cephalic vein to a point below the upper border of the tendinous insertion of the pectoralis major. The deltoid and the pectoralis major are separated, exposing in the upper border of the wound the coraco-brachialis, and in the lower angle the upper part of the insertion of the pectoralis major. The upper three-fourths of this insertion is divided in order to expose the head and neck of the bone. The humerus is then rotated outward and a portion of the insertion of the subscapularis muscle, stretched over the head of the humerus, is divided. The capsule is thus laid bare.

In Burrell's second case a portion of the anterior wall of the capsule three-eighths of an inch wide and three-fourths of an inch long was excised, and the wound was closed with sutures. The incised muscles fell into apposition when the arm was fixed to the side. Burrell operated on two patients by this method with perfect success.

Similar operations in which the lax capsule was overlapped and sutured without opening it, have been performed, by Ricard in 1892 and by Steinthal in 1895.[1]

Congenital Deformities of the Elbow.

Congenital displacement of the ulna is one of the rarest of deformities. The displacement is usually incomplete, and it is associated with laxity of the ligaments.

Congenital displacement of the radius is much more common. Thirty cases collected from the literature have been reported by Bonnenburg.[2] The symptoms are similar to those of the traumatic dislocation. The deformity is often overlooked in childhood, and as it causes no great disability, treatment is not usually desired. In several instances the head of the radius has been removed with a favorable effect in increasing the range of supination.

Cubitus Valgus, Cubitus Varus.

Cubitus valgus, in which the forearm is abducted at the elbow and cubitus varus, in which it is inclined in the other direction, are occasion-

[1] Burrell and Lovett, Am. Jour. Med. Sci., Aug., 1897.
[2] Zeits. für Orth. Chir., Bd. 2.

ally seen as congenital deformities. They are, in most instances, associated with laxity of the ligaments.

Similar deformities are not uncommon during the progessive stage of rhachitis, but they usually disappear when the erect attitude is assumed and when the arms are relieved of the strain of supporting the body in the sitting posture. What may be called normal cubitus valgus, is common among women, and in certain instances it may be exaggerated to deformity. Acquired cubitus varus is usually the result of direct injury.

Subluxation of the Wrist.

A peculiar displacement of the hand forward and to the radial or ulnar side, described by Madelung[1] as "spontaneous subluxation," is sometimes seen in young subjects whose occupation may require constant use of the flexors of the hand and fingers. In these cases the lower extremities of the bones of the arm project on the dorsal surface, the flexor tendons are prominent on the palmar aspect and limit the range of extension of the hand, the wrist may be slightly enlarged and the ligaments seem to be relaxed. The symptoms, aside from the deformity, are weakness and sensations of discomfort about the dorsum of the wrist.

Etiology.—The predisposing causes of the affection are, apparently, relaxation of the ligaments and, possibly, slight preëxisting rhachitic deformity of the same character. The exciting causes are occupation or injury. In some instances there is a slight forward bending of the lower extremity of the radius, due, apparently, to irregularity in growth at the epiphyseal junction.

Treatment.—The treatment is rest, massage, forcible manipulation in the direction of extension and a support of leather or other material to hold the hand in the extended position until the tendency to deformity is checked.

Congenital Deformities at the Wrist.

Simple congenital dislocation of the wrist is extremely rare. Displacement of the wrist and hand is usually associated with defective development of the bones of the arm, and the deformity is usually classed as club hand.

Club Hand.

Congenital distortions of the hand may be divided into four primary varieties, according to the direction in which the hand is turned, viz.:

1. Forward or palmar.
2. Backward or dorsal.
3. Lateral to the radial side—radial.
4. Lateral to the ulnar side—ulnar.

Lateral and antero-posterior distortions occur also in combination.

Etiology.—There are two distinct varieties of club hand:

[1] Archiv f. Klin. Chir., Bd. 23.

1. In which there is simple distortion caused apparently by abnormal fixation and pressure in utero.

2. In which the deformity is associated with defective development of the radius or ulna and often with congenital abnormalities of other parts.

In the palmar and dorsal distortions the bones of the arm are usually normal. The lateral deviations of the hand are often caused by defective formation of the radius or ulna, and thus they correspond to talipes due to absence of the tibia or fibula.

According to Hoffa,[1] 39 cases of the former and but 6 of the latter are recorded; in but one case was there entire absence of the ulna.

Fig. 306.

Club hands and club feet.

Of the 39 cases of radial club hand 19 were of both sides. These statistics, however, by no means represent the relative frequency of the deformity. From the writer's observation it would appear that radial club hand is nearly as common as the deformity of the foot caused by absence of the fibula, of which, according to Potel, there are 200 recorded cases. The ulnar form of club hand is less frequent even than the deformity due to defective formation of the tibia.

The most important form of club hand is, then, that due to absence or to defective formation of the radius. As in talipes valgus due to absence of the fibula, the tibia is short and often bent sharply forward, so in this form of club hand the ulna is usually short and bent inward. The hand may be perfect in formation, but as a rule the thumb is ab-

[1] Lehrb. der Orth. Chir., p. 481.

sent or rudimentary and other adjoining bones, together with the corresponding ligaments and muscles, may be absent also. (Fig. 307.)

The hand occupies practically a right-angled relation to the ulna and as this bone is usually bent inward as well, the direction of the hand is often reversed and is parallel to the forearm. As a rule the hand is also somewhat bent forward, so that the deformity might be described as radio-palmar. (Fig. 308.)

Treatment.—In those forms of club hand in which the structure is normal the deformity may be overcome as a rule by manipulation, and support by the plaster bandage or otherwise. Massage and muscle training are required in the after-treatment.

In slighter cases of radial club hand, due to defective development,

FIG. 307.

Congenital absence of radius and the bones of the thumb. (WEIGEL.)

it may be possible by manipulation and tenotomy to replace the hand in its normal position, but this is unlikely. As a rule an operation on the ulna will be necessary, together with division of the contracted tissues. Sayre [1] removed a portion of the carpus and implanted the head of the ulna at the point of resection. McCurdy [2] sawed through the ulna, leaving the extremity in relation to the carpus and sutured the proximal fragment and the semi-lunar bone to one another. Thomson [3] replaced the hand by subcutaneous tenotomy and by the removal of a cuneiform section of bone from the lower end of the ulna.

The operation of splitting the ulna into an ulnar and radial portion

[1] Trans. Amer. Orth. Ass'n, Vol. VI.
[2] Ibid., Vol. VIII.
[3] Ibid., Vol. IX.

and implanting the carpus between the two, has been performed by Bardenhauer.[1] The immediate effect of the various operative procedures was favorable, but no final results have been reported.

In any event some form of apparatus must be used during childhood at least, to support the hand, whether the operation has been successful or not; and at best the arm will be short, and the thumbless hand will be weak as compared with the normal.

Fig. 308.

Congenital club hands, showing the short and deformed forearms, also bow legs. (Gibney.)

Congenital Contraction of the Fingers.

The most common form of congenital contraction is that of the little finger, on one or both hands, which is semi-flexed, apparently, because of deficiency of the skin. In other instances several fingers may be similarly affected.

Treatment.—If treatment by manipulation and splinting is begun early the deformity may be overcome by lengthening the contracted tissues. In later life the prospect of perfect cure by any method of treatment is slight, because of the strong tendency to recontraction after the finger has been straightened.

Webbed Fingers.

In the most common form of this deformity two or more fingers are joined by skin and fibrous tissue to the first phalangeal joints, but sometimes throughout the entire length of the fingers.

In other instances the web may be thicker, containing muscular fibers from the apposed parts and, occasionally, the bones of the two fingers may be joined to one another, even to the finger nails.

Etiology.—The cause of the deformity is arrest of development before the fingers have been separated from one another, thus the thumb, which is differentiated from the other parts of the hand as early as the seventy-fifth day of intra-uterine life, is rarely involved, as compared with the fingers which are separated from one another at a later period.

Treatment.—In all but the extreme grades of deformity the fingers may be separated from one another; operative treatment being conducted according to the rules of plastic surgery.

[1] Verhand. der deutsch. Gesells. für Chir., 23 Kong., 1894.

Congenital Displacements of the Phalanges and Distortions of the Fingers.

These deformities are not particularly uncommon. They should be treated by manipulation and by splinting at as early a period as is practicable. Other congenital deformities and malformations of the hand do not call for extended comment.

Trigger Finger.

Synonyms.—Jerking Finger, Snapping Finger.

This affection was first described by Nélaton under the title Doigt à Ressort. On extending the closed hand one finger remains flexed. If the flexion is overcome by greater muscular effort or by passive force the finger flies back to complete extension with a sudden snap or jerk, hence the name. In well-marked cases the same difficulty and the subsequent snap is experienced in flexing the finger. The middle and ring fingers are more often affected but sometimes the thumb or the fifth finger may be involved.

The patient usually complains somewhat of stiffness and pain in the finger but the interference with its function is the principal symptom.

Etiology.—The usual explanation of the disability is interference with the motion of the tendon in its fibrous sheath, either because of a reduction of its calibre due to injury or inflammation, or to an enlargement or irregularity of the tendon itself. In most instances the obstruction appears to be in the neighborhood of the metatarso-phalangeal joint.

The duration of the affection is indefinite.

Treatment.—If the obstruction appears to be of inflammatory or traumatic origin it may be treated by splinting and later by massage. In confirmed cases the tendon and the sheath may be explored in the hope of finding and removing the obstruction.[1]

Mallet Finger.

Synonym.—Drop Finger.

This is caused usually by a blow upon the terminal phalanx which ruptures or weakens the attachment of the extensor tendon at the base of the phalanx so that it is habitually flexed to a right angle with the finger.

The treatment must be by incision and reattachment of the tendon to the periosteum.

Baseball finger (Abbe) is the reverse displacement of the terminal phalanx which is dislocated backward, forming a bayonet-like deformity.

If reposition is impossible open incision should be employed to correct the deformity.

Dupuytren's Contraction.

Dupuytren's contraction is a deformity of the hand caused by contraction of a part of the palmar fascia and of its prolongations to one or

[1] The bibliography is large. More recent articles are those of Jamin, Cent. für Chir., June 6, 1896, who reports 31 cases and A. Necker, Beiträge zur Klin. Chir., Bd. X., p. 469.

more of the fingers. The fingers are flexed as a consequence, to a greater or less degree, and in advanced cases they may be drawn to close contact with the palm. The ring finger is most often primarily affected but as a rule two or more fingers are somewhat involved in the contraction.

In a large proportion of the cases both hands are involved, but not as a rule simultaneously, the contraction beginning in the second hand several years after the deformity in the first.

Pathology.—The characteristics of the deformity are explained by the anatomy of the palmar fascia. This consists of a strong central portion, and two thinner lateral parts that cover the muscles of the thumb and little finger. It is made up of longitudinal fibers continuous with the tendon of the palmaris longus and the annular ligament. It divides into four processes that are attached to the digital sheaths, to the integument at the clefts of the fingers and to the superficial transverse ligament. Prolongations of the fascia pass along the lateral aspect of the fingers and are attached to the periosteum and to the tendon sheaths of the first and second phalanges.

The cause of the contraction appears to be a chronic plastic inflammation of a part of the fascia, which becomes hypertrophied, and finally contracts, drawing the finger toward the palm in the manner described.

Etiology.—The etiology is uncertain.

The contraction is much more common in men than in women and it is practically confined to middle and later life. It is claimed that the deformity is more common among those who are subject to gout or rheumatism. It appears also to be an hereditary affection in certain instances. Injury or irritation of the palmar tissues, incident to certain occupations, would seem to explain the disproportionate liability of the sexes to the affection.

Symptoms.—The first symptom is usually the deformity; the patient finds it impossible to completely extend one or more of the fingers, the tissues about the base of the finger seem stiff, and when it is forcibly extended a hard, elevated cord may be felt extending from about the center of the palm to the second phalanx, most prominent at the metacarpo-phalangeal articulation.

To this the skin is adherent, and as the contraction increases it is thrown into elevated ridges. Later, other bands appear if the contraction affects, as it usually does, other portions of the fascia. In many instances no pain is experienced unless the contracted fascia is forcibly stretched or is pressed upon. In other cases complaint is made of neuralgic pain in the hand and even in the arm and back. Occasionally the first symptom to attract attention may be a sensitive nodule in the skin at the base of the finger.

The contraction usually increases slowly until the finger that is most affected is drawn to the palm.

Treatment.—The deformity may be overcome by division or preferably by removal of the contracted bands of fascia. The finger is then supported in an attitude of slight flexion until the circulation is adjusted to the new position.

CHAPTER XVII.

DISEASES OF THE NERVOUS SYSTEM.

From the orthopædic standpoint, only those diseases that directly interfere with the function of locomotion or that cause deformity, and for which local treatment is of benefit, are of especial interest. Even this limited class is not often seen in the early or progressive stage and it is rather with the effects of a disease that is no longer present than with the disease itself that the orthopædic surgeon is especially concerned.

The relative importance of this branch of orthopædic work may be illustrated by the statistics of the Hospital for Ruptured and Crippled. In a period of ten years, 1890–1899, forty-two thousand one hundred and twenty-four new patients were examined in the out-patient department. Excluding cases that cannot properly be classed as orthopædic, thirty-eight thousand four hundred and nineteen remain. In two thousand four hundred and forty-one of these the nervous system was involved (6.3 per cent.). Two thousand and twenty-eight of the cases were in young children; four hundred and thirteen of the patients were more than fourteen years of age and of this number two hundred and sixty-six were adults.

Anterior poliomyelitis furnished about 75 per cent. of the total number. In 20 per cent. the cerebrum was involved and 5 per cent. were miscellaneous cases. In 611 cases treated in a period of about two years there were 463 cases of poliomyelitis, 121 cases of paralysis of cerebral origin, 16 cases of obstetrical paralysis, 4 cases of pseudo-hypertrophic muscular paralysis and 7 miscellaneous cases.

These statistics will explain the selection of diseases of the nervous system for consideration and the order in which they are described.

Acute Anterior Poliomyelitis.

Synonym.—Infantile Paralysis.

Pathology.—Anterior poliomyelitis is an acute inflammatory process of the area of the gray matter of the anterior cornua supplied by the anterior spinal arteries involving both the neuroglia and the cells, and resulting in degeneration and atrophy of the interstitial tissue and of the ganglion cells.[1]

In the acute febrile form, comprising about three-fourths of the cases, there is an actual inflammation; in the other type, in which there are no constitutional evidences of disease, the symptoms may be caused by hemorrhage or by thrombosis.

[1] Starr, Loomis-Thompson, System of Practical Medicine.

The minute changes in the cord are characteristic of inflammation, distended blood vessels, minute hemorrhages, infiltrating leucocytes and serum. In the early stage the motor cells become cloudy in appearance, later they are swollen and lose their distinct outlines. The degenerative changes affect both the cells and neuroglia ; the affected gray matter shrinks and the nerve fibers atrophy, and the cord becomes distinctly smaller at the seat of the disease. When the motor conductivity of the cells is cut off, the muscles which are supplied by them are paralyzed and waste away. The circulation in the affected parts is impaired, contractions and distortions appear and growth is retarded.

Etiology.—The etiology of the disease is obscure. Exposure to heat, sudden chilling of the body, over-fatigue, injury and the like, are thought to be predisposing causes, while the direct cause of the inflammatory disease of the cord is supposed to be some form of infection.

The disease affects the sexes in nearly equal numbers, and those in perfect health as often as those whose resistance is enfeebled. It sometimes occurs in epidemics and there are instances in which several members of the same family have been affected, but usually the cases are isolated and no adequate cause for the disease can be assigned.

Age.—Acute anterior poliomyelitis is essentially a disease of infancy. This is illustrated by the combined statistics of several observers tabulated by Starr.[1]

	1st year.	2d year.	3d year.	4th year.	5th year.	6th year.	7th year.	8th year.	9th year.	10th year.
Seeligmuller	20	25	18	1	1	2	0	0	0	0
Galbraith	17	38	15	4	1	0	0	0	0	0
Sinkler	44	92	55	29	9	2	3	6	0	3
Gowers	21	21	25	9	17	4	2	6	4	0
Starr	16	38	27	9	10	4	2	2	4	3
	118	214	140	52	38	12	7	14	8	6

472, or 77 per cent., before the fourth year.

It is far more common during the warm months than at other seasons, as is illustrated in 452 cases tabulated by Starr.[2]

January	8	
February	5	
March	20	
April	9	
May	18	
June	49	327, or 72 per cent., during the four months, June to September.
July	97	
August	116	
September	65	
October	42	
November	11	
December	12	
	452	

[1] Loomis-Thompson, System of Practical Medicine. [2] Loc. cit.

Distribution of the Paralysis.—The lower extremities are far more often paralyzed than the upper. In 416 of 595 cases, tabulated by Starr, the paralysis was limited to the lower extremities, as contrasted with 53 cases in which the upper extremities were alone involved.

	Duchenne.	Seelig-müller.	Sinkler.	Starr.	Total.
Both legs	9	14	107	40	170
Right leg	25	15	63	20	123
Left leg	7	27	62	27	123
Right arm	5	9	5	7	26
Left arm	5	4	8	4	21
Both arms	2	1	1	2	6
All extremities	5	2	35	5	47
Arm and leg same side	1	2	26	4	33
Arm and leg opposite sides	2	1	1	4	8
Trunk	1	0	22	3	26
Three extremities	0	0	10	2	12
	62	75	340	118	595

Symptoms.—The disease is usually divided into several stages:

1. The stage of onset. This is usually attended by constitutional symptoms, by fever and headache, even by convulsions and delirium; by vomiting and intestinal disturbance, or occasionally by severe pain. In most instances the elevation of the temperature is not extreme, nor is the constitutional disturbance severe, and but for the paralysis, the attack would be considered as one of the ordinary illnesses so common in childhood. In some cases however the fever is high and there may be convulsions and prolonged unconsciousness, while in others there may be no premonitory symptoms whatever, the child is apparently well at night, but wakens in the morning paralyzed.

In many instances the weakness caused by anterior poliomyelitis is not discovered until the child begins to walk, when the awkward gait, or limp, or the distortion of a foot, may make it evident.

In a few hours, or a few days, after the first symptoms of the disease the paralysis appears; its area may extend slowly after it is recognized or its extreme limit may be reached at once. This original paralysis is always greater than that which finally persists. The duration of the first stage may be from a few hours to a week.

2. Then follows a stationary period, lasting from a week to a month; the constitutional symptoms cease, but the paralysis remains.

3. This is succeeded by the stage of partial recovery, lasting from one to six months or longer. The muscles which were paralyzed because of the secondary congestion and exudation about the local myelitis, recover their power in whole or in part, while those muscles supplied from the area in the cord in which the nerve cells have been destroyed, waste away. At this time the contractions and distortions in the paralyzed part appear.

4. The chronic stage. This may be considered to last until adult

age, or until the ultimate damage to the individual, due to the retardation of the growth and unbalancing of the mechanical equilibrium of the body, may be summed up.

The sensation of the paralyzed part is not affected except in the extreme cases. The temperature is lower from the first. In many instances the limb is not only cold, but it is congested and blue. These circulatory disturbances are caused primarily by the interference with the vaso-motor system, but they are confirmed later by the atrophy of the muscles and by the permanent contraction of the blood vessels. Thus, in general, the impairment of the circulation corresponds to the degree of the paralysis, but not absolutely so. In certain cases the paralysis may be very limited in extent, and yet the limb may be cold and congested, while in others in which the loss of power is much greater the temperature is but slightly lowered and the color remains normal. The same is true of retardation of growth. In most instances the ultimate shortening of the limb corresponds to the degree of the paralysis, and consequent loss of function ; but occasionally cases are seen in which the growth is markedly retarded although but few of the muscles are paralyzed.

Diagnosis.—It is doubtful if the diagnosis of acute anterior poliomyelitis could be made before the stage of paralysis. But after the paralysis has appeared there should be little difficulty in interpreting the symptoms. It is a disease usually of acute onset, followed by paralysis of certain muscular groups or of entire members. It is a flaccid paralysis, the reflexes are lost, the muscles no longer contract under faradism and the reaction of degeneration is present ; the tissues waste and the circulation is impaired in the affected parts.

It is usual to consider, first, in differential diagnosis the paralyses of cerebral origin, but this is more for the purpose of calling attention to the essential differences between the two, than because they are likely to be confounded by one acquainted with the ordinary characteristics of cerebral and spinal disease.

Paralysis of Cerebral Origin in Childhood.—In paralysis of cerebral origin, the common form is hemiplegia. It usually follows convulsions and the intelligence may be impaired. The paralysis is not complete, nor is it limited to groups of muscles ; it is rather powerlessness or impairment of function, due to loss of cerebral control. The reflexes are increased and limbs are stiffened, not flaccid. The electrical reactions are not lost or changed in quality. Paralysis of cerebral origin may be also paraplegic or diplegic in its distribution, but in these cases the general characteristics are the same as in the hemiplegic form, except that the intelligence is more markedly affected.

Other Forms of Spinal Paralysis.—Transverse myelitis is very uncommon in childhood. In this disease the distribution is equal, the reflexes are at first increased and sensation as well as motion is lost.

Pott's Paraplegia.—In this form of paralysis, also, the distribution is equal, the reflexes are increased and the signs of the disease of the spine are always present.

Rheumatism and Joint Disease.—In orthopædic practice, anterior poliomyelitis is not often seen in the early stage, unless pain is a prominent symptom, when the disease may be mistaken for rheumatism or for some form of joint disease. Cases of this type are not uncommon. The muscles are sensitive to pressure and the movements of the joints cause discomfort. In certain instances the paralysis may not be apparent on the first examination; when it does appear the diagnosis is, of course, established, therefore the characteristics of disease of the joints need not be detailed.

Multiple Neuritis.—Multiple neuritis is usually a sequel of infectious disease, or of metallic poisoning. In the cases due to metallic poisoning with lead or arsenic, the paralysis usually begins in the extensors of the hands and feet, and is symmetrical in its distribution. This is true also of the limited forms of paralysis following contagious diseases in which the dorsal flexors of the feet are most often involved. In multiple neuritis there is usually local sensitiveness lasting a longer time than in poliomyelitis, and the paralysis is gradual in its onset and the sensation, as well as motion, is affected.

Diphtheritic Paralysis.—Diphtheria is the most common cause of general weakness terminating in paralysis, but in these cases there is usually a history of the preceding disease. The paralysis appears first in the muscles of the throat and neck, and a general and increasing weakness precedes for a considerable interval the complete loss of power.

Weakness. Pseudo-Paralysis.—Weakness caused by rhachitis, or so-called pseudo-paralysis, due to this or to other affections, is readily distinguished from actual paralysis by pricking the part with a pin when the muscular contraction will be evident. This test of function is of value in showing the distribution of the paralysis. Loss of power in the tibialis anticus muscle, for example, causes valgus resembling closely the ordinary valgus due to simple weakness. In simple weakness the child withdraws the foot from the point of the pin, and the ability to move it in all directions is very evident; but if the tibialis anticus muscle is paralyzed, the foot is always flexed in the abducted attitude. The same test may be made for paralysis of other muscles or muscular groups. It is a test that is easily applied and that is especially useful in the examination of young children.

Obstetrical Paralysis.—Paralysis of the arm is infrequent as compared with that of the lower extremities. This form might be mistaken for obstetrical paralysis, but the history of the disability and its distribution should make the diagnosis clear.

Prognosis.—Only in very rare instances does the disease of itself cause death. The prognosis as to function depends upon the area of the destructive disease of the cord, and upon the treatment of the weakened or disabled part.

As has been stated the extent of the primary paralysis is very much greater than that which ultimately remains when the inflammatory changes about the diseased area in the cord have subsided.

THE ELECTRICAL TEST.—During the early stages of the disease the degree of final paralysis may be fairly estimated by the electrical reaction. Within a week after the initial paralysis the reaction to the faradic current in the muscles and nerves is lessened and finally is lost. If the faradic irritability is retained in the paralyzed muscles, or if it is merely diminished, recovery may be predicted. The muscles which no longer react to the faradic irritation may still be made to contract by the galvanic current. In normal muscles the reaction is greatest at the closing of the negative pole. In the paralyzed muscles the reaction is slower, it requires greater stimulation and the contraction is greater at the closing of the positive pole. This is known as the reaction of degeneration. The loss of faradic reaction and the change in

FIG. 309.

Anterior poliomyelitis. Extreme flexion deformity at the hips inducing the quadrupedal attitude. (GIBNEY.)

the galvanic reaction indicate that the function of the affected muscle is lost, although certain of its fibers may in time regain their power.

The Effects of Paralysis of Different Muscles and Groups of Muscles upon Function.—The interest in anterior poliomyelitis lies in its immediate and ultimate effect upon the functional ability of the individual. These effects may be classified as **Deformity of the part directly involved. The general effects of weakness, deformity and loss of growth upon the body as a whole.**

CAUSES OF DEFORMITY.—The deformities of anterior poliomyelitis are caused :

1. By the force of gravity.
2. By the unopposed action of the muscles whose power remains.

3. By functional use.

All these and other less important causes of deformity are of course combined in most instances. The relative importance of each factor varies, according to the muscular group that is involved, with the age of the patient and with the work to which the part is subjected. The influence of the different factors can be studied best in the foot.

Muscular Action and Gravity.—In by far the larger number of cases, one or more of the anterior muscles of the leg, dorsal flexors of the foot, are involved. This is illustrated by the statistics of acquired talipes, tabulated elsewhere, in which the equinus predominates over the varieties of calcaneus deformity in a proportion of three to one.

If the anterior muscles are paralyzed in a child before the walking age, the foot drops under the influence of the force of gravity into the attitude of equinus. If this attitude is allowed to persist, the muscles on the posterior aspect of the limb accommodating themselves to the habitual attitude, in time become structurally shortened. In such cases the equinus deformity is caused by the force of gravity; it is increased by muscular action and it is fixed by muscular adaptation. That deformity is not caused directly by muscular action is shown by the fact that it may be prevented by stimulating the paralyzed muscles from time to time with galvinism, or even by passive motion to the limit of dorsal flexion. Deformity is thus prevented, not by opposing muscular action, but by preventing muscular adaptation and structural change, by stretching the active muscles to their full limits from time to time. In the instance cited, gravity and muscular activity are combined in the production of equinus, but in other instances, gravity and muscular power may be opposed to one another. If, for example, the calf muscle is paralyzed while the anterior group retains its power, the deformity of calcaneus does not appear until the child begins to use the foot, when the peculiar helplessness calls attention to the disability, if the diagnosis has not been made before. Thus it is that equinus may be present when the child is still in arms, while the opposite deformity develops much more slowly.

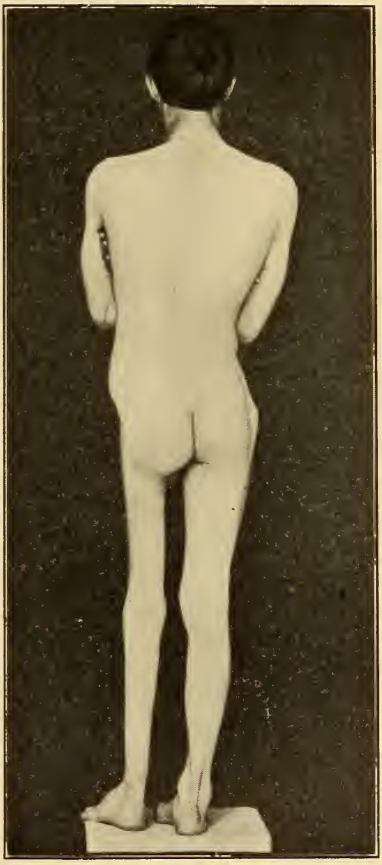
Habitual Posture.—There are other cases in which every vestige of muscular power is lost, in which the foot dangles. In this class there is no adaptive shortening of the muscles to fix the foot in the habitual attitude, consequently deformity is slow in making its appearance; it is not often extreme, and it becomes fixed only by the structural shortening of the inactive tissues, the ligaments and fasciæ. There are, of course, other causes for habitual posture than the force of gravity and muscular action, such as, for example, the position of convenience in which a weak or disabled part might be placed, but such causes of deformity may be considered as instances of functional use or rather of adaptation to local weakness.

Functional Use as a Cause of Deformity.—Thus far the force of gravity, unbalanced muscular power and the structural changes in the tissues have been considered in the etiology of deformity, as it might develop in infancy. When, however, the patient stands and walks,

existing deformities are exaggerated and distortions are developed and confirmed by the weight of the body falling on the unbalanced part, and by the action of the muscles in the attempt to supply the function of those that are paralyzed. Thus it is that deformity develops far more rapidly when a fair amount of muscular power remains, than when it is completely lost. (See talipes.)

Subluxation.—Aside from the distortions due to the causes that have been mentioned, there are others caused simply by weakness; for example, when laxity of ligaments and the failure of muscular support permits distortion of a limb and subluxation or even displacement at a joint. (Figs. 311, 312.) Actual displacement is uncommon and occurs practically only at the hip. In such cases there is usually flexion deformity of the limb. The femur is suspended by the contracted tissues attached to the anterior superior spine. This unyielding band forms a fulcrum by means of which force applied at the knee may cause sudden displacement of the head of the femur inward or upward and backward.

FIG. 310.



Anterior poliomyelitis. Duration seven years. Showing atrophy, and slight lateral curvature of the spine. 2¼ inches of shortening.

Deformities of the Upper Extremity.—Deformities caused by paralysis of the muscles of the shoulder and upper arm are usually slight because the part is not subjected to the strain of weight-bearing, and because the force of gravity is opposed to muscular contraction. In these cases the loss of support and the tension on the capsule allows a considerable separation of the joint surfaces so that the atrophied head of the humerus may be displaced forward or backward; but there is not often fixed displacement, and consequently distortion due to this cause is very unusual.

Paralysis of the muscles of the forearm and of the hand is followed after a time by deformity of the fingers caused primarily by unopposed muscular action, secondarily by accommodation and atrophy.

Deformities of the Neck.—Paralysis of one or more of the muscles

of the neck may induce a paralytic torticollis. This is, however, extremely rare.

Deformities of the Trunk.—Paralysis of the muscles of the trunk may induce distortion and extreme lateral curvature of the spine. This curvature is not usually caused, as might at first appear, by contraction of the active muscles and thus a bending of the trunk with a con-

FIG. 311.

Anterior poliomyelitis causing genu recurvatum. (See Fig. 312.)

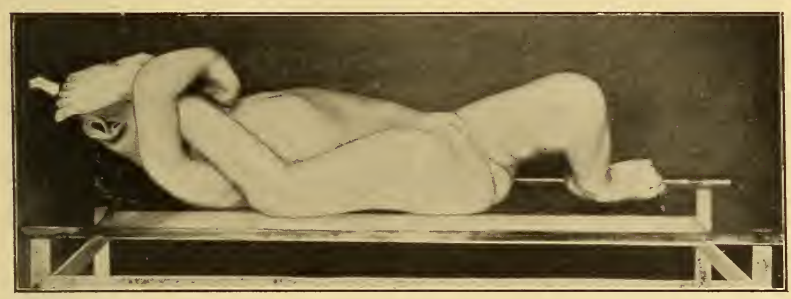
vexity toward the weaker side. As a rule, the curvature is, as a whole, in the opposite direction. This is explained by the fact that if the paralysis is extensive enough to cause distortion of the trunk, and if it is limited to one side, the muscles of respiration on that side are also paralyzed or weakened so that the chest wall becomes inactive and collapses while the opposite side increases in volume and lung capacity in taking on the extra work; thus it expands, drawing the weaker and

atrophied side into a concavity. The same effect is observed when the arm and the shoulder muscles are paralyzed, the spine bending toward the side that is still active.

Paralysis of the posterior group of muscles, if extreme, might cause a kyphosis. Paralysis of the muscles of the abdomen may induce lordosis, but in this group of cases the lower extremities are usually involved and the secondary distortions due to posture and to functional use mask the direct effect of the paralysis of the muscles of the trunk. And again the over-use of the shoulder muscles in patients whose lower extremities are paralyzed, and the suspension of the body on crutches in walking modify the ultimate effects in these cases in which the paralysis is wide-spread in its area. (See lateral curvature.)

Retardation of Growth and Secondary Deformities.—The effects of anterior poliomyelitis are not limited to the paralysis and to atrophy of the muscles, but all the component tissues of the affected limb are involved as well. The bones become relatively atrophied and their

FIG. 312.



Anterior poliomyelitis. Paralysis of muscles at the hip allows subluxation of the femur. The same patient as in Fig. 311.

growth is retarded to a degree proportionate to the extent of the paralysis and to the functional disability that has resulted. It has been stated however that retardation of growth does not always correspond to the amount of paralysis. In some instances paralysis of a single muscle which does not seriously compromise the function of the part is attended with greater shortening of the limb than in other cases in which the paralysis is far more extensive. Thus it may be inferred that certain cells in the spinal cord are especially concerned in the growth and nutrition of the bones and that interference with the function of these cells may not correspond absolutely to the extent of the destructive process. However this may be, it is certain that atrophy and retardation of growth are much greater when a limb is not used than when by the aid of apparatus it has been enabled to carry out, in part at least, its proper function. It is evident also that retardation of growth will be more marked during the period of rapid development; thus the younger the patient the greater should be the ultimate inequality of the limbs.

Retardation of Growth.—The ultimate shortening varies from one to three inches. In the slighter degrees of paralysis affecting the leg, the shortening may be less than an inch, but when the thigh muscles are paralyzed also, it may be much more. (Fig. 310.) This inequality is usually very evident in the size of the two feet.

When both limbs are paralyzed so that locomotion is very seriously interfered with, the retardation of growth is especially marked and the contrast between the trunk of the patient and the attenuated lower extremities is very striking.

Secondary deformities must include besides those already mentioned the compensatory distortions of the trunk that may follow paralysis of the limbs. Thus a short leg might cause a lateral curvature of the spine or great flexion contraction of the thigh might induce abnormal lordosis. As a matter of fact, the final effects of disabilities of this character are very complex and are influenced by many factors of which only a general indication is practicable.

Treatment.—The treatment of the acute stage of anterior poliomyelitis is symptomatic. If the diagnosis has been made, such measures as would tend to relieve the congestion about the diseased area should be employed; cathartics, sedatives, and counter-irritation of the spine, for example. When the acute symptoms have subsided, local treatment to maintain as far as is possible the nutrition of the muscles, to prevent deformity and to relieve the strain upon the weakened tissues is indicated. The nutrition of the parts may be improved by massage, by muscle beating, by the direct application of heat to the cold extremities, and by the use of galvanism, as long as it will produce contractions in the paralyzed muscles.

Deformity may be prevented by moving each joint to the limit of the range of motion in all directions several times a day and by supporting the limb with appropriate apparatus. Deformity in those parts in which it is favored by muscular action and by the force of gravity, appears much more rapidly than is generally supposed. The indications of equinus, for example, are apparent in a very few weeks after paralysis of the anterior muscles of the leg. The first indication of such deformity in this class is the discomfort caused by passively moving the foot toward dorsal flexion. This limitation of the range of motion rapidly increases, and as it increases it is confirmed by muscular adaptation and finally by structural shortening.

The Principles of Mechanical Treatment.—The object of a brace is to prevent the deformity due to weakness, to utilize the muscular power that remains and thus to enable the disabled member to carry out its function. As each muscle has an essential function, the paralysis of any muscle must be followed by a certain disability and usually by deformity. Muscles vary in importance as they do in strength and the ultimate disability caused by paralysis may be predicted very accurately by one who is familiar with this function.

Paralysis of the Anterior Muscles of the Leg.—Paralysis of the anterior leg group causes the so-called steppage gait, the toes

drag on the floor when the limb is swung forward and this necessitates an awkward lifting of the knee. The result of such paralysis is equinus. Slight equinus has a tendency to throw the knee backward, "recurvatum," in order that the patient may place the entire sole on the ground. More marked equinus obliges the patient to bear the weight entirely on the front of the foot and causes flexion both at the knee and hip. If but one of the muscles of the anterior group is paralyzed the tendency to equinus is in so far lessened, but there is an inclination to lateral distortion. Paralysis of the anterior muscles causes an awkward gait and often deformity, but the propelling force of the limb remains. The indication for support is simple, to prevent the foot from dropping to the extent that incommodes the patient, or practically to hold the foot at a right angle with the leg.

Fig. 313.

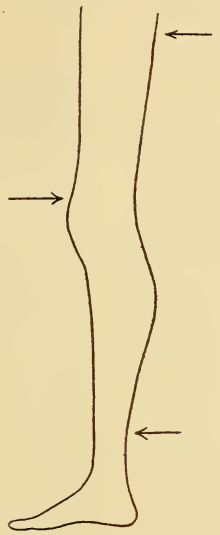
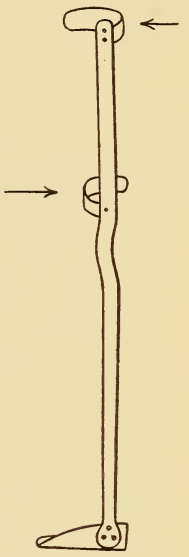


Fig. 314.



The Judson brace for paralysis of the quadriceps extensor muscle in connection with deformity of the foot.

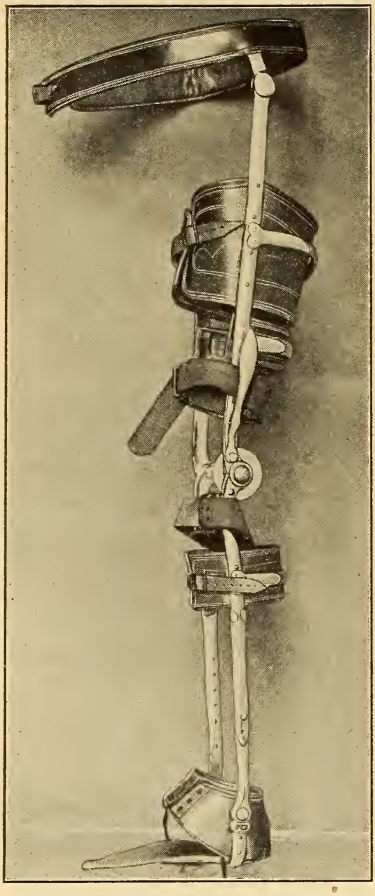
Paralysis of the Posterior Muscles of the Leg.—If, on the other hand, the calf muscles are paralyzed the resistance of the foot is lost and it is simply dorsi-flexed when weight is thrown upon it. Thus the brace must be arranged to prevent dorsal flexion, and strong enough to support the strain which is transmitted from the foot plate of the brace to the front of the leg. The various weaknesses and deformities of the foot and the means of treating them are described at length elsewhere. (See talipes.)

Paralysis of the calf muscles not only affects the foot, but it weakens the knee as well, and genu recurvatum is often a secondary effect. In many instances therefore it will be necessary to support the knee as well as the ankle during the earlier stages of the treatment.

Paralysis of the Thigh Muscles.—Paralysis of the quadriceps extensor muscle causes primarily a peculiar gait. The patient, unable to extend the leg upon the thigh, throws or swings it forward, then locks the joint by direct contact of the bones and by the resistance of the posterior tissues, by inclining the body somewhat forward as the weight falls upon it. In this manner again the knee may be over-extended. Or if extension is checked by shortening of the tissues,

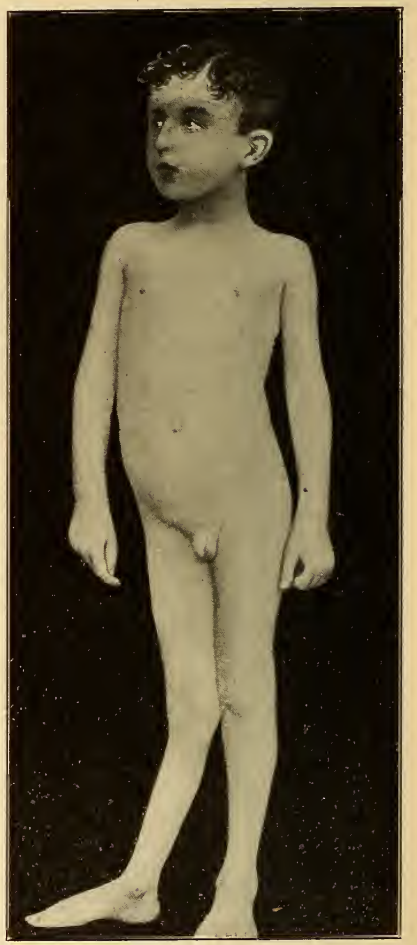
induced possibly by habitual assumption of the sitting posture, the patient being unable to lock the joint effectively by complete contact of the bones, often trips and falls because of the insecurity of the support. When in the normal subject the weight is borne upon one leg in the attitude of rest, in which the muscles are thrown out of

Fig. 315.



A brace for complete paralysis of the limb, showing a form of lock at the knee and a limited joint at the ankle.

Fig. 316.



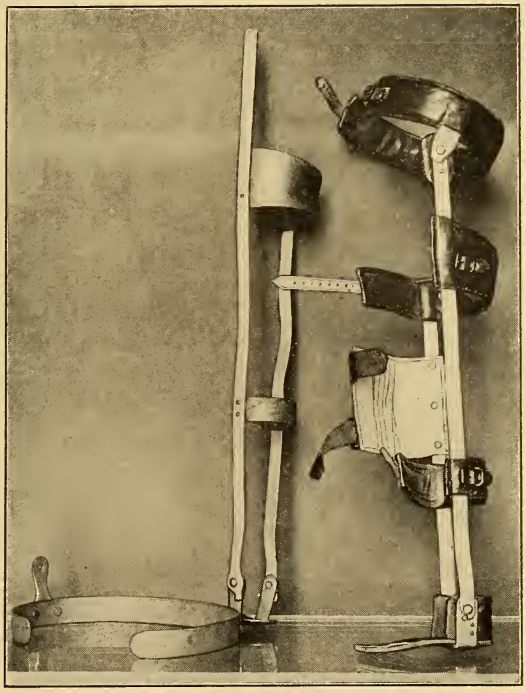
Anterior poliomyelitis. Paralysis of the anterior and posterior muscles. Right leg.

action, the knee joint is locked, but the insecurity of this support is illustrated by the school boy's trick of striking the back of the knee with the hand when, the muscles being taken unawares, the person falls to the ground. This insecurity is constant when the extensor of the leg is paralyzed.

Paralysis limited to the quadriceps extensor muscle is, however,

very unusual. In almost all cases some of the leg muscles are involved also, and the brace usually must serve to support the foot as well as the knee. In its ordinary form such a brace is constructed of two lateral upright bars, reaching nearly to the pubes on the inner and to the trochanter on the outer side, joined to one another by bands passing beneath the thigh and the calf, and attached to a light steel foot plate. If the dorsal flexors of the foot are paralyzed the ankle joint is arranged to allow dorsal flexion, but to prevent extension beyond the right angle. If the calf muscle is paralyzed a reverse catch is used, or the uprights are attached directly to the foot plate without a joint

FIG. 317.



Brace for complete paralysis of the anterior muscles of the limb ; before and after covering.

(Fig. 314) ; or the so-called limited joint allowing only a few degrees of motion in either direction is used. (Fig. 315.) (See talipes.) In the treatment of young children the joint is also omitted at the knee, the limb being firmly held in the extended position during the active period. (Figs. 314 and 317.) This is of advantage because the joint is the weakest part of the brace and soon becomes loose under the severe strain to which it is subjected. In older subjects a joint is arranged with a spring catch, the brace being held in the straight position when the patient is walking about, but allowing flexion when the sitting posture is assumed. This is of course a great convenience.

(Fig. 315.) In fitting the brace the lateral bars should be adjusted to support the limb without uncomfortable pressure, and the joints should be exactly opposite the normal centers of motion. The thigh and leg bands should be properly fitted to the contour of the soft parts so that half the limb is contained within them. These are smoothly covered with leather and the limb is held in position by leather bands that complete the circumference. Other bands are applied across the front or back of the limb, either to support it or to fix it firmly in place. In the ordinary brace without the joint at the knee, there are three anterior bands, one across the front of the thigh, another across the leg, and the third, a wide knee cap, supports the greater part of the strain. (Fig. 317.)

Paralysis of the Muscles of the Hip.—The effect of paralysis of the muscles about the hip is difficult to describe, as in these cases many other muscles are usually involved. If all the muscles are paralyzed the thigh dangles. This is however very unusual, for the tensor vaginæ femoris almost always retains its power and is one of the causes of flexion deformity which is so often present in cases of this character.

Paralysis of the ilio-psoas muscle makes it impossible for the patient to flex the thigh directly. If the adductors are paralyzed he must lift the thigh with the hand when adduction is desired. Paralysis of the glutei is made evident by the atrophy and by the weakness of the extending power of the limb.

The distribution of the paralysis of the muscles of the hip may be ascertained by placing the patient in the recumbent posture; the leg is then lifted from the table, and by placing the thigh in different positions the ability of the patient to move it may be tested, in older subjects by voluntary effort, in the younger ones by pricking the part slightly with a pin.

General weakness of the muscles of the hip causes an awkward, insecure gait accompanied usually by outward rotation of the limb, and as has been stated there is almost always accompanying paralysis of other muscles of the extremity. In such cases a pelvic band must be attached to the leg brace. The pelvic band is made of sheet steel of about 18 gauge, two inches wide, fitted to the pelvis which it encircles midway between the crest of the ilium and the trochanter. At this point it is attached to the brace by a free joint. (Fig. 317.) When the band is accurately adjusted and strapped firmly about the pelvis, the necessary security is assured and the attitude of the limb in walking can be regulated. If greater support is desired a perineal band may be applied as described in the chapter on disease of the hip joint.

If both limbs are paralyzed double braces must be used. If the muscles of the lower part of the back are much weakened the pelvic band may be replaced by a corset or some form of back brace. Fortunately these cases are uncommon.

Paralytic Scoliosis.—Paralytic scoliosis requires the support of corsets or braces as a rule, such as are used in the treatment of other forms of distortion of the back. (See lateral curvature.)

Paralysis of the Arm.—Paralysis of the arm is uncommon and treatment is rarely demanded.

In some instances a shoulder support may be of service or a brace to hold the arm at a right angle if the biceps is paralyzed. If the muscles of the scapula retain their power the operation of arthrodesis might be of service in fixing the dangling joint, and the same operation might be useful at the elbow. It is of course evident that one of the lower extremities, although hopelessly weakened, may be braced so that it may serve as a simple prop to bear weight, but as the function of the arm is quite different, extensive paralysis of its muscles makes it practically useless to the individual.

Operative Treatment. The Reduction of Deformity.—In a large proportion of the cases of anterior poliomyelitis the patients are not seen by the orthopædic surgeon until months or years have elapsed since the original attack. They are then brought for treatment because of secondary deformity often of an extreme degree. At least half of the cases of talipes are due to this cause and with the deformity of the foot are often combined other distortions varying in degree with the extent of the paralysis. Many of the patients hobble about on a distorted foot, others use crutches and in a smaller number the only method of locomotion is creeping on all fours. In the cases in which the patient has habitually used crutches allowing the paralyzed limb to "dangle" there is usually marked flexion at the three joints. The thigh is flexed upon the pelvis, the leg is flexed upon the thigh and the foot hangs downward and inward (plantar-flexed) in an attitude of equino-varus. No matter how extreme the paralysis of a lower extremity may be the limb may be made useful as a prop, when properly braced and this prop will enable the patient to dispense with the use of crutches and thus free the arms from unnecessary work. Even if both limbs are paralyzed they may at least serve as supports to enable the patient to stand erect and to propel himself with the aid of crutches. If the limb has been disused for a long time, the atrophy is usually extreme, the bones are fragile and the growth has been greatly retarded as compared with those limbs in which deformity has been prevented and in which the weight of the body has been sustained in functional use. In this class of cases the first step must be the reduction of deformity; the foot must be brought to a right angle with the leg, the limb must be brought to the straight line, and the flexion at the hip must be overcome in order to enable the patient to stand erect without bending the spine forward into an extreme compensatory lordosis.

Acquired deformity of the foot is far less resistant than is the congenital form and by tenotomy and the proper application of force it may be readily straightened, usually at one sitting.

The flexion contraction at the knee may be overcome also by careful and persistent manual stretching combined, if necessary, with division of the contracted tissues on the posterior aspect of the joint.

The flexion deformity at the hip is usually fixed by the contraction of the tissues about the anterior superior spine of the ilium, including

the tensor vaginæ femoris muscle which is rarely paralyzed. These tissues together with the fascia may be divided subcutaneously, or by open incision if necessary; after which the deformity may be reduced by gradual forcible extension of the thigh while the pelvis is fixed by flexing the other limb upon the body. When the contraction deformities are reduced, lateral deviation at the knee is corrected, if it be present, in the same manner, and the bony points having been carefully protected by padding a long spica plaster bandage is applied to fix the limb.

The lesser degrees of deformity may be reduced by other means, for example, by repeated applications of plaster bandages under slight corrective force, or by manipulation, or by braces and bandaging.

Paralytic knock knee may be overcome by the Thomas knock knee brace, and this brace when attached to a pelvic band is a useful form of support in the routine treatment of paralysis of the legs. (See knock knee.)

The Thomas caliper knee brace is another cheap and useful support. It is of especial service when there is flexion or lateral deformity of the limb. (Fig. 230.)

When distortion has been overcome and when functional use has been made possible by proper support, the development of active muscles which had been thrown out of use by the distortions, and of those in which part of the muscular substance has been retained is surprising. In many of these cases the distortions which developed during the temporary paralysis had alone prevented recovery and this latent power may be revived even after years of disuse. Thus in many instances prognosis is impossible until the deformities have been corrected and until the limb, properly supported, has been enabled to resume its function.

Tendon Transplantation.—This operation is best adapted to the treatment of distortions of the foot caused by paralysis of the muscles of the leg, and the procedure is described at length in that section.

In certain cases of paralysis of the quadriceps extensor when the sartorius muscle has remained active, it may be utilized to better advantage by attaching it to the insertion of that muscle, as suggested by Goldthwait. Muscle or tendon transplantation may be of service, in exceptional cases, in other situations.

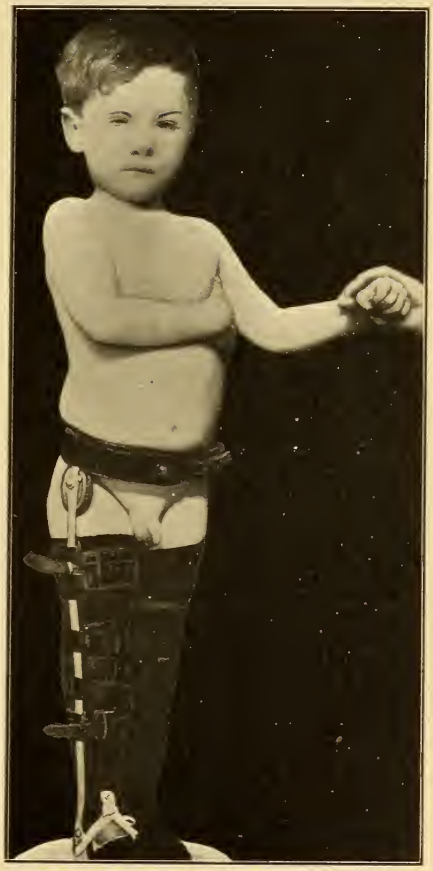
Paralysis of the muscles of the arm and hand is unusual. The operation of tendon shortening combined with transplantation of the tendons of one or more active muscles may be of service in the treatment of wrist drop, and opportunities may suggest themselves in other situations whenever it is possible to utilize the muscular power to better advantage.

Arthrodesis.—As has been stated of tendon transplantation, arthrodesis is of greatest service at the ankle joint where it may serve to fix the foot at a right angle with the leg. (See talipes.) In exceptional cases arthrodesis or excision at the knee may be advisable in the older patients, but in young subjects the strain upon the long, weak lever formed by the two bones will almost always induce deformity.

Arthrodesis at the hip might be of service in complete paralysis of the pelvic muscles, at the shoulder when the muscles attached to the scapula are active, and in exceptional cases at the elbow and wrist to assure an improved position.

Osteotomy.—In rare instances, particularly in the extreme deformities in the adult, osteotomy of the femur at the hip or knee may be necessary in order to overcome resistant distortion.

FIG. 318.



Leg brace with pelvic band. Double uprights. No joint at knee. For paralysis of the anterior thigh and leg muscles.

Recapitulation of Treatment.—This consists in support and electrical stimulation of the muscles during the period of recovery, together with a suitable brace to hold the limb in the best possible position for usefulness when the final extent of the paralysis has become evident. With the support, any treatment that will improve the nutrition of the part is of service; massage and muscle beating are of especial value. The limb in which the circulation is deficient should be protected from the cold by proper covering, and its nutrition may be improved by the direct application of heat, the hot-air or hot-water bath both being useful. Above all else, functional use, which is made possible by apparatus, is of the first importance in preserving and stimulating whatever muscular power remains; and special gymnastic exercises to this end may be employed if practicable. The prevention of deformity during the growing period is of great importance. Every morning and night the joints of the paralyzed part should be passively moved to the normal limits in all directions in order to prevent the gradual limitation of the range of motion which is the first indication of deformity. Lateral deviation of the limb may be prevented by passive manipulation and by the support that may be exercised by modification of the brace that may be employed. Braces should be strong, and as simple as may be in construction. Elastic bands and springs, applied with the design of replacing paralyzed muscles are of

little practical use, since they are ineffective in action, difficult to adjust and easily disarranged. The parent, when treatment is begun, must be impressed with the fact that a brace must be strong enough to serve its purpose even though its weight be objectionable; that its period of usefulness is limited and that it must be replaced when it is outgrown; that the breaking of a brace from time to time is unavoidable, and that such accidents, in so far as they are evidences of the functional activity of the patient, are favorable indications.

Careful supervision of the patient, even though the weakness is not great, will be necessary during the period of growth. The contrast between the development and symmetry, the muscular power and practical utility of a limb that has received this care and supervision, and one that has been neglected, is sufficiently striking to impress any one with the necessity for this tedious and apparently never-ending treatment.

Thus, in this as in other chronic diseases and disabilities, the character and the duration of treatment, its object and the final results that one may expect to attain by it, should be explained to the parents when the care of the patient is undertaken.

CHAPTER XVIII.

DISEASES OF THE NERVOUS SYSTEM.—*Continued.*

CEREBRAL PARALYSIS OF CHILDHOOD.

Spastic Paralysis.

Cerebral paralysis or palsy is in orthopædic practice second only in frequency and importance to anterior poliomyelitis. It is however entirely different in its distribution and in its effects. It is a form of disability that is characterized by motor weakness, by stiffness and loss of control, rather than by paralysis. It affects entire members and it results in atrophy, contractions and deformity.

It may involve half the body, hemiplegia.

It may be limited to the lower extremities, paraplegia.

It may involve both the upper and lower extremities, diplegia.

In rare instances but one extremity is affected, monoplegia.

Distribution.—In 452 cases of cerebral paralysis analyzed by Peterson,[1] 332 were of the hemiplegic type, 73 were of the diplegic type and 46 were of the paraplegic type. In 121 cases observed at the Hospital for Ruptured and Crippled, 63 were paraplegic or diplegic and 58 were hemiplegic. The hemiplegic form of paralysis is usually acquired; the diplegic and paraplegic forms are usually congenital.

Etiology and Pathology.—Cerebral paralysis may be divided into two classes, the congenital and the acquired.

Congenital Paralysis.—Paralysis of intra-uterine origin may be the result of mal-development or injury or a secondary effect of intercurrent disease of the mother. Paralysis caused by injury at birth is usually the result of rupture of blood vessels of the meninges due to prolonged labor or to the pressure of instruments.

Acquired Paralysis.—Acquired paralysis may be due to hemorrhage, embolism or thrombosis or to disease. Sachs[2] presents the following classification of causes and effects.

Paralysis of intra-uterine origin.

Large cerebral defects—true porencephaly.

Hemorrhages of intra-uterine origin. Softening.

Agenesis corticalis.

Paralysis occurring during labor.

Meningeal hemorrhage—very seldom intra-cerebral. Resulting conditions: meningo-encephalitis chronica; sclerosis; cysts; atrophies; porencephalies.

[1] American Text-book of Diseases of Children.

[2] Sachs, The Nervous Diseases of Children, 1895.

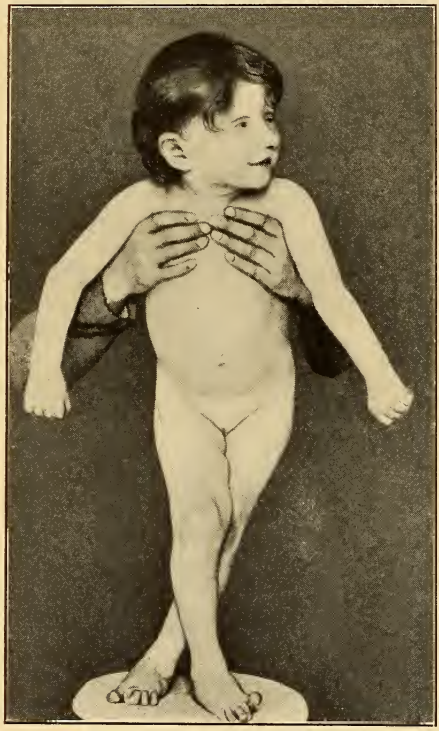
Paralysis acquired after birth.

1. Meningeal hemorrhage—very seldom intra-cerebral. Embolism; thrombosis in marantic conditions, and occasionally from syphilitic endo-arteritis. Results of these vascular lesions, cysts; softening; atrophy; sclerosis, diffuse and lobar.
2. Chronic meningitis.
3. Hydrocephalus.
4. Primary encephalitis (Strümpell).

General Symptoms.

Motor.—The effect of the lesion of the brain and of the secondary changes in the cord is to impair the voluntary control of the limbs supplied from the affected area, and at the same time the inhibition of the higher centers is impaired or lost. Thus, together with the loss of power, there is usually a corresponding exaggeration of the reflexes causing a spastic rigidity of the limbs. This induces distortion, which finally becomes fixed by the adaptive changes in the tissues. As the centers for the nutrition of the paralyzed parts are not involved, the muscles do not waste and the circulation is but little affected. Thus the atrophy as compared with paralysis of spinal origin (anterior poliomyelitis) is comparatively slight, and this together with the loss of growth is due rather to the general effects of the disease and to the loss of function than to the direct influence of the nervous lesion.

Fig. 319.



Congenital cerebral diplegia. Idiocy.

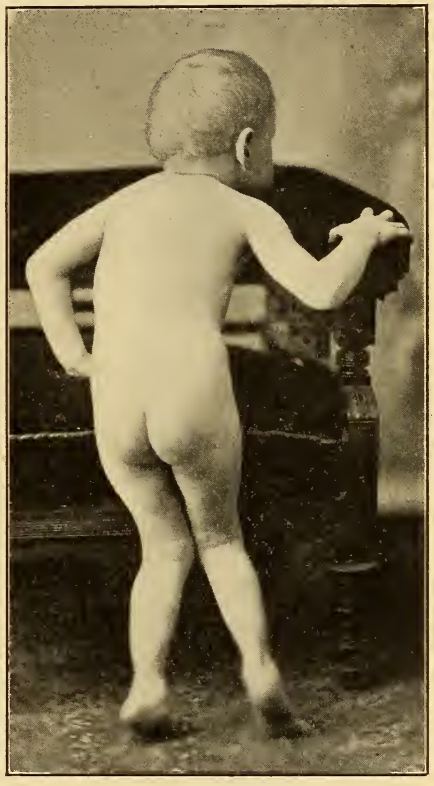
Mental.—In this form of paralysis the lesion is of the brain and the direct injury of its structure or the interference with its development is likely to cause mental impairment. This mental impairment is usually more marked in the paraplegic or diplegic than in the hemiplegic form, because in the latter but half the brain is involved, and because the injury or disease occurs at a later period of its development. So also the mental development is usually less interfered with in the para-

plegic than in the diplegic type. For although both hemispheres were originally involved in all probability, yet the recovery of power in the arms shows that the injury was less extensive than when the weakness persists in one or both of the upper extremities.

It is estimated that in 50 per cent. of the hemiplegic cases the patients are feeble-minded, although comparatively few (13 per cent.) are idiotic. In the paraplegic and diplegic forms of paralysis about 70 per cent. of the patients are feeble-minded and from 40 to 50 per cent. are idiotic. (Sachs.)

Epilepsy is an accompaniment of about 45 per cent. of all forms of cerebral paralysis and in 20 per cent. of the cases athetoid or associated movements in the paralyzed parts persist. (Peterson.)

FIG. 320.



Spastic paraplegia.

Congenital Paralysis.

The congenital form of cerebral paralysis is often seen in orthopædic clinics, because the effect of the lesion of the brain in retarding both the mental and physical development first attracts the attention of the mother. Thus infants are brought for examination because they are unable to sit or stand or to talk at the usual time. In certain instances the cause of the physical weakness is simple idiocy. In such cases the vacant expression, the inability of the child to recognize even its mother, the extreme weakness and the absence of the spastic rigidity of the limbs, will make the diagnosis clear.

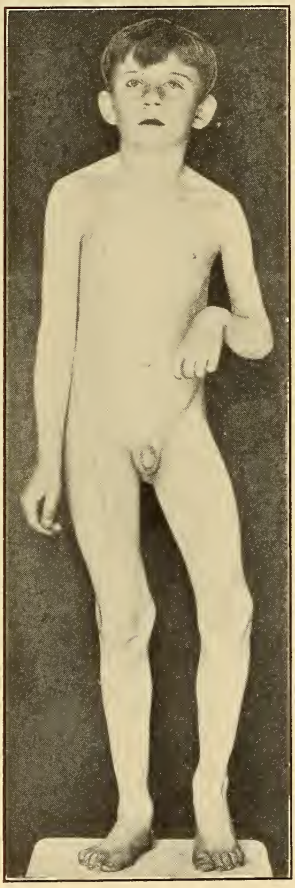
In another class of cases the weakness appears to be caused simply by retarded cerebral development. The patient is apathetic and weak. In these cases also there is no evidence of paralysis, but the evident intelligence of the patient distinguishes this type from the idiotic class.

In cerebral paralysis the child may be idiotic, or simply apathetic, or apparently normal in intelligence, but it is always weak and in the sitting posture the spine is usually bent backward into a long more or less rigid curve. It makes no effort to stand and when placed in the

erect posture it will be noticed that the thighs are usually pressed closely against one another and that the feet are extended. The limbs are "stiff." There is a peculiar resistance to flexion at the extended joints, which slowly gives way under steady pressure. This is the characteristic spastic rigidity. (Fig. 320.)

DEFORMITIES.—These children usually begin to stand, and to walk at about the third year or later with an awkward shuffling gait; the limbs are usually flexed, adducted and rotated inward; the knees touch one another or the legs may be crossed, while the feet turn inward in a persistent attitude of slight equino-varus. The equilibrium is very easily disturbed, partly because of the deformities and partly because of direct lesion of the brain. In the majority of the congenital cases the paralysis is paraplegic in its distribution; perhaps fifteen per cent. are of the hemiplegic variety and in a somewhat larger number the paralysis is diplegic in distribution. (Fig. 319.)

FIG. 321.



Acquired cerebral hemiplegia.

As has been stated, in a certain number of cases the intelligence is not impaired, but more often the patients are distinctly feeble-minded. They are very nervous, easily startled, emotional and are often unable to speak distinctly, yet it is interesting to note that this peculiar emotional excitability often passes for an extreme degree of brightness of intellect and quickness of perception. In fact parents often remain unconvinced that the child is lacking in mental power until it reaches an age when comparison with other children makes this conclusion inevitable.

Acquired Paralysis.

As in the adult cases the common form of acquired cerebral paralysis in childhood is hemiplegia. About two-thirds of all the cases occur in the first three years of life; and in about 20 per cent. of the cases the affection of the brain is a complication of infectious disease. The onset is usually sudden and is accompanied in the majority of the cases by fever, convulsions and loss of consciousness. When the child regains consciousness the paralysis of the arm and leg is at once evident, and in about 20 per cent. of the cases the face is paralyzed also.

DEFORMITIES.—At first the paralysis is a simple powerlessness, but

soon the exaggeration of the reflexes is evident. As has been stated, there is a loss of voluntary power and an increase of the reflexes or stiffness of the paralyzed members. They are no longer competent to assume the more difficult attitudes and functions, and these are replaced by those that are simpler ; thus flexion becomes habitual.

In typical hemiplegia the foot is plantar-flexed and adducted. The leg is flexed on the thigh and the thigh on the trunk, and with the flexion, adduction is usually combined. The arm is held against the body, the forearm is flexed upon the arm in an attitude midway between pronation and supination. The hand is flexed upon the arm and inclined toward the ulnar side and the fingers are clasped over the adducted thumb.

Disability.—The loss of power is not absolute ; in most instances the patient is able to walk with an exaggerated limp, dragging the stiffened and contracted leg which serves as a prop rather than as an active support. So also the control of the upper extremities is in part retained ; the patient is able to abduct the arm, to partly extend the forearm, sometimes to extend the fingers and to abduct the thumb, but the power to dorsi-flex the hand and at the same time to extend the fingers is not usually retained in a case of this character.

Loss of Growth.—The growth of the patient as a whole is usually retarded, and checked to a certain extent, by the lesion of the brain. There is in addition a certain degree of inequality in the growth of the two halves of the body. This inequality is more marked in the arms than in the legs. Shortening to the extent of an inch in the lower extremity is not often exceeded, but the growth of the arm and hand may be very markedly checked. This disproportionate loss of growth in the upper over the lower extremity, although it may be explained in part by the situation of the lesion of the brain, depends more directly upon the interference with function. The lower extremity is rarely disabled to an extent that prevents its use in locomotion, consequently its nutrition is preserved, whereas the same degree of paralysis of the arm utterly unfits it for its more difficult functions and it becomes a useless appendage. With the disuse of function there is a corresponding diminution of nutrition and a consequent atrophy and loss of growth.

Extreme deformity and disability, as in the type described, is rather unusual. In many instances there is almost complete recovery from the paralysis, only an awkwardness and slowness of movement, combined with an increase of reflexes and a slight hemiatrophy of the body persists. In some cases a slight degree of equinus is the only deformity ; in others weakness of the arm may persist although complete control of the lower extremities has been regained.

The final effect of the paralysis is almost always more marked in the upper than in the lower extremity ; thus when contractions and deformities of the lower extremity are present the arm and hand are often practically disabled.

Treatment. 1. **Hemiplegia.**—The treatment from the orthopædic standpoint consists in stimulating the nutrition of the paralyzed parts,

in preventing deformity and in improving the functional ability. The results of treatment are, of course, very greatly influenced by the mental condition of the patient. If the mental power is not impaired one may count upon the efforts of the patient to aid the surgeon, whereas if the patient is idiotic there is but little encouragement for active treatment. If the patient is seen before the secondary contractions have appeared, deformity may be prevented in great degree by regular massage and by passive movements in the directions opposed to the habitual positions. If the spastic rigidity is slight the control of the movements of the leg may be made easier by the use of a light jointed leg brace attached to a pelvic band. By this means the movements are controlled and the excessive expenditure of nervous energy necessary to guide the limb may be lessened. This support should be supplemented by massage and exercise, and in the milder type of paralysis the control of the limb may be greatly improved.

In many instances the patients are not seen until late childhood, when the deformities have become fixed. The foot is usually turned inward and downward (equino-varus), there is flexion at the knee and often flexion and adduction at the hip, the resistance of the contractions being dependent upon the duration of the deformity. In such cases the distortions must be corrected by force and by division of more resistant tissues including often the tendo Achillis, the plantar fascia, and in many instances the hamstrings, and the adductors of the hip. The limb is then fixed in a plaster of Paris bandage for a sufficient time to overcome the more direct tendency to deformity. When the bandage is removed a brace is of service in guiding the limb, and regular massage and forcible passive movements together with proper exercises should be employed whenever practicable. In this class of cases the deformities may be overcome in most instances, but there is a tendency toward flexion at the knee, and stiffness and awkwardness in movement usually persist.

In many of the milder hemiplegic cases the only deformity is of the foot. This should be treated by division of the tendo Achillis and by support for a time until the deformity habit has disappeared.

If the arm is but slightly affected proper exercises will greatly improve its ability. In the more extreme cases in which the fingers are clasped over one another, treatment is practically useless. In the third class in which the patient has the power of extending the fingers only when the wrist is flexed, the power of dorsi-flexion may be restored or improved by transplanting the flexors of the carpus on the radial and ulna border to the extensors which have been over-lapped and shortened to the proper extent. The transplantation of other tendons may be of service, but the operation is limited in usefulness for the reasons stated.[1] Athetoid movements of the hand and arm may be relieved somewhat by prolonged fixation in a plaster bandage, or by arthrodesis at the wrist joint.

2. **Paraplegia.**—The treatment of spastic paraplegia is much more

[1] Townsend, Trans. Am. Orth. Ass'n, Vol. XIII., 1900.

difficult than that of hemiplegia because the disability is very much greater and because the mental impairment is usually more marked.

In general the treatment in infancy is by massage and by manipulation. When the child shows a desire to walk an attempt should be made to relieve the spastic contractions. In certain instances complete correction of all deformities, followed by prolonged fixation of each joint in the over-corrected attitude, may be of service. (Fig. 322.) This

FIG. 322.

Cerebral paraplegia, second stage in treatment. The long replaced by the short spica. This patient at the age of eight years was unable to stand without assistance. The spastic contractions and deformities were overcome by tenotomies and by force, and a double long spica bandage was applied. This was worn for eight months. It was then replaced by the bandage shown in illustration. Six months later this was removed. There is at present no deformity, and the child walks fairly well.

may be combined with multiple tenotomies if the contractions are more resistant. The advantage of tenotomy, aside from the simple correction of deformity, is that by elongation of the tendon the response to the exaggerated motor impulses is lessened and an opportunity for more effective control is afforded. Transplantation of tendons from the flexor to the extensor aspect of the limb has been performed in several instances but the value of the procedure is still in doubt. Except in the very mild cases of paraplegia, braces are of little value. The trunk is

not as a rule deformed except in the diplegic cases in which the mental impairment is great. Manipulation, massage and posture are of some service in correcting and preventing this distortion.

Prognosis.—It is stated by Peterson [1] that the patients in whom the paralysis is paraplegic or diplegic usually die before the twentieth year, and that but few of those in whom it is hemiplegic reach the age of forty. This prognosis applies, it may be assumed, rather to the extreme cases accompanied by mental impairment than to the milder forms. In almost all cases the patient even if idiotic is finally able to stand and to walk. As a rule there is for a time a gradual improvement in motor power and in mental control as well. It is evident that in a class in which mental enfeeblement is so common and in which epilepsy is present in so large a proportion of cases, simple care and moral and mental training are of great importance.

Orthopædic treatment, although it has no direct action upon the lesion in the brain, certainly has an indirect effect upon the mental as well as upon the physical condition of the patient. When deformity has been corrected and when contractions have been overcome, functional use requires less mental effort; and motor control may be still further improved by drilling the patient constantly in simple movements. Such exercises improve the motor communications and the ability of the paralyzed part as well.

Progressive Muscular Atrophy.

Progressive muscular atrophy, as the term implies, is a progressive wasting of the muscles, with corresponding loss of power, terminating finally in paralysis and deformity.

Under this title are included two varieties of disease.

1. The myelopathic form in which there is primary disease of the spinal cord.

2. The myopathic form in which the disease is primarily of the nerve terminals and the muscular fibers.

The second variety is usually designated as muscular dystrophy to distinguish it from the spinal form.

Myelopathic Paralysis or Atrophy.—The myelopathic form of muscular atrophy, the Aran-Duchenne type, usually begins in the small muscles of the hands and spreads from the periphery to the trunk. Fibrillary twitching of the affected and unaffected muscles is fairly constant and the reaction of degeneration may be present. The disease is practically limited to adults and from the orthopædic standpoint it is of little interest. In another form, the Charcot-Marie-Tooth type, usually classed with the muscular atrophies, the paralysis may begin in the muscles of the legs, causing deformity of the equinus or equino-varus variety. The lesion of the cord in muscular atrophy is of the anterior cornua, and resembles closely that of the subacute form of anterior poliomyelitis.

[1] Trans. Am. Orth. Ass'n, Vol. XIII., 1900.

Myopathic Paralysis or Muscular Dystrophy.—The myopathic form of muscular atrophy may be preceded by apparent hypertrophy (pseudo-hypertrophic muscular paralysis), it may be primarily atrophic, or the two forms may be combined.

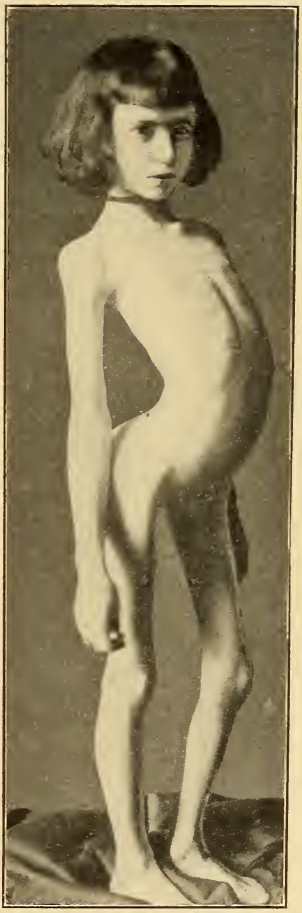
It differs from the myelopathic form in several particulars. It is a disease of childhood. It is often hereditary and its distribution is different.

The affection is divided according to the distribution into two main varieties.

Fig. 323.

Progressive muscular dystrophy, showing the enlargement of the calves and the atrophy of the shoulder muscles.

Fig. 324.



Progressive muscular dystrophy, facio-scapulo-humeral type. Extreme lordosis and flexion contractions at the hips.

1. The facio-scapulo-humeral type (Landouzy-Dejerine), in which the muscles of the face and shoulder girdle are primarily affected. (Fig. 324.)

2. The juvenile form of Erb, in which the muscles of the back and of the upper arms are first involved.

The etiology, pathology and clinical course of the atrophic does not differ essentially from the pseudo-hypertrophic form.

Pseudo-hypertrophic Muscular Paralysis.—Pseudo-hypertrophic paralysis is characterized by progressive weakness of the muscles of the trunk and of the legs associated with apparent hypertrophy of the calves due to a deposit of fat in the wasting muscles. (Fig. 323.)

The symptoms are caused by a degenerative atrophy of the nerve terminals and of the muscular fibers and an increase of the connective tissue and replacement of the muscular substance by fat.

Diagnosis.—The interest in this latter affection from the orthopædic standpoint lies in the diagnosis in the early stage of the affection. At this time the patient is evidently weak, he walks with an awkward, shambling gait and climbing stairs is especially difficult. There is usually an increased lordosis and a peculiar swaying or waddle, a disinclination to stoop and an evident difficulty in regaining the erect posture, and there may be discomfort or pain referred to the lumbar region. If the disease is advanced, the peculiar hard, resistant enlargement of the calves, combined, it may be, with atrophy of the muscular groups of the upper extremity, and weakness of the muscles of the back, makes the diagnosis evident, but in young children the disease may be mistaken for **Pott's disease, simple weakness,** or **postural deformity.** Although there is a superficial resemblance to the general symptoms of Pott's disease, yet the specific signs of disease of the vertebræ, pain and muscular spasm, are absent.

Weakness, a result of malnutrition or disease, is general in character and its cause is usually apparent; it is, of course, not accompanied by local hypertrophy. Retarded cerebral development causes general weakness as far as inability to stand is concerned, but the cause is in this class also usually apparent. Postural deformities in childhood always have a cause, and as one is not content to treat a deformity without ascertaining its cause, this search will bring to light the peculiar symptoms of the disease.

Treatment.—In certain instances the discomfort referred to the back, due in part to the lordosis, may be relieved by a light spinal support. Massage and muscle training may enable the patient to utilize the remaining power to best advantage.

In the later stages of the disease there may be secondary deformities, most marked in the feet which may be fixed in the equinus or equinovarus attitude. This deformity may be corrected by tenotomy or otherwise, if the patient has not already become so weak that walking or standing is impossible.

Hereditary Ataxia. Friedreich's Disease.

Hereditary ataxia is an ataxic paraplegia caused by sclerosis of the posterior and lateral columns of the spinal cord. The early symptoms are incoördination and weakness of the legs; later similar symptoms appear in the upper extremities and speech is affected. In well-marked

cases there is usually distortion of the feet toward equinus or equino-varus, and occasionally a posterior or lateral curvature of the spine. In one case recently under treatment at the Hospital for Ruptured and Crippled, the rectification of the deformity of the feet was at least of temporary benefit.

Neuritis.

Localized neuritis after contagious disease or from other causes may result in temporary weakness or paralysis of the dorsal flexors of the foot, cause toe drop and finally deformity. In such cases the foot should be supported by a brace in normal position. This not only prevents deformity, but it hastens the cure by preventing tension upon and structural lengthening of the weakened muscles. The same treatment may be applied for wrist drop from metallic poisoning. The hand should be supported by a suitable brace in the attitude of dorsi-flexion until the muscles have recovered their power. Obstetrical paralysis has been considered under affections of the shoulder.

Hysterical Joint Affections and Deformities.

Functional Affections of the Joints.

So-called hysterical or functional affections may be divided into two groups.

1. Those in which there is no actual disease or weakness.
2. Those in which the symptoms of disease or injury, or of their effects, are exaggerated and prolonged.

The first class of cases is small, the second is large.

Simulation, whether voluntary or involuntary, of organic disease can deceive only those who are not familiar with the characteristics of the disability that is simulated. Every disease has certain well-defined symptoms which can no more be imitated by a well person than a disabled part can suddenly take on the normal appearance and function.

"Hysterical Hip."

The hysterical hip is supposed to simulate actual tuberculous disease.

Diagnosis.—The symptoms of actual disease of this joint are pain, limp, limitation of motion due to reflex muscular spasm, muscular atrophy, distortion and in the later stages the local signs of a destructive process; for example, heat, swelling, abscess and displacement of the parts, shortening of the limb and the like. As these later symptoms could not be simulated they need not be considered.

In actual disease symptoms and effects follow one another in regular sequence and correspond closely to the pathological conditions that cause them. Pain is not a pronounced symptom; it is more likely to be concealed than exaggerated and it is usually referred to the knee. Local sensitiveness is not a pronounced symptom, and it is often absent. Distortion of the limb when it occurs in the early stage, before the de-

structive changes are advanced, is caused by reflex muscular spasm and whenever this distortion is great the reflex muscular spasm, which involves every muscle about the joint, is also great; so that the range of motion in the joint is small, and motion may be absolutely prevented. With the distortion there is always a corresponding atrophy of the muscles of the limb. If pain is present it is usually worse at night than during the day.

The hysterical simulation of hip disease is characterized by an exaggeration of the symptoms and by absence of the physical signs of disease. There is usually an exaggerated limp, great distortion, marked local sensitiveness and pain, but absence of muscular spasm, atrophy or other signs of disease.

The essential differences between actual disease and its simulation may be presented more effectively by contrasting them.

Disease.	Simulated Disease.
Pain, intermittent or absent or concealed; referred to the knee. Often worse at night.	Patient often complains bitterly of pain, referred to the hip or to the entire limb. Worse during the day.
Local sensitiveness, often absent or caused only by deep pressure.	Often extreme, caused by the slightest manipulation; the skin is hyperæsthetic.
Limp, corresponds to the acuteness of the symptoms or to the distortion; slight in the early stage, but constant.	Exaggerated, does not correspond to the physical signs, may be intermittent.
Distortion, slight in the early stage, is dependent on the degree of muscular spasm and upon the quality of the disease; is constant and cannot be reduced by manipulation.	Often great in the early stage, bears no relation to the physical signs; is intermittent, may disappear at night; can be reduced by manipulation.
Muscular spasm, always present.	Absent.
Muscular atrophy, always present.	Slight or absent.
Local signs of a destructive disease, often apparent at an early stage.	Absent.

The age of the patient, the history of the supposed disease and the other evidences of hysteria that are usually present, will confirm the diagnosis.

The same principle applies of course to the differential diagnosis of simulated disease at other joints. The knee and the hip are those that are most often involved.

Hysterical Deformities.

"**Hysterical Club Foot.**"—Local deformity distinct from simulated joint disease is sometimes seen. Several cases of this character in

which the foot was distorted have been under treatment at the Hospital for Ruptured and Crippled, recently. The differential diagnosis is simple.

TALIPES is either congenital or acquired. Congenital talipes and all the acquired varieties, other than those of paralytic origin, may be at once excluded from consideration. Paralytic talipes in the vast majority of cases begins in early childhood when it is either caused by anterior poliomyelitis or is one of the deformities of cerebral hemiplegia or paraplegia. When these are excluded, the remaining causes of deformity are very limited. Every variety of nervous disease has well-defined symptoms. If actual paralysis is present the muscles atrophy and the electrical reactions are changed. In hysterical contractions the muscles do not atrophy and the electrical reactions are unchanged.

"Hysterical Scoliosis."—A case was recently under observation at the Hospital for Ruptured and Crippled, in which distortion of the trunk persisted for more than a year, and until a suit for damages was finally decided. In this case there was a most exaggerated lateral twist of the spine so that the shoulder approached the pelvis. The deformity however was not fixed, but it could be completely reduced when the patient was in the recumbent posture. There was no paralysis, no persistent spasm, no evidence of disease or injury. The deformity was of a nature that could not be explained by any conceivable lesion, and all the signs of hysteria were present.

Treatment.—The principles of the treatment of pronounced hysteria of which simulated joint disease or deformity are but unusual manifestations are considered at length in medical and neurological works, and the subject does not call for especial mention here. It is evident, of course, that an unequivocal diagnosis must be the first and essential step toward cure. In this class of cases apparatus is not often indicated unless the deformity has persisted for so long a time that the disused muscles have become incapable of performing their proper functions.

FUNCTIONAL AFFECTIONS OF THE JOINTS.

"Neurotic Joints."

In this class, although there is no absolute distinction between it and the preceding variety, there is usually a physical basis for the symptoms, however much they may be exaggerated.

The patients are not usually hysterical, in fact hysteria in the ordinarily accepted sense is uncommon, and although the larger proportion of patients are women, yet men and children are by no means exempt from the so-called functional affections.

It must be borne in mind also that many of these cases are classed as neurotic simply because the cause of the symptoms is not apparent. It is only within a few years that the slighter degrees of weak foot and its effects have been recognized, and it is probable that such cases, together with anterior metatarsalgia, the painful fascia of the con-

tracted foot, achillodynia and the like might be considered as neurotic by one unfamiliar with their symptoms. And it may be inferred that as diagnosis becomes more accurate the more restricted will become the class of cases of purely imaginary disability, in so far at least as the locomotive apparatus is concerned.

A "neurotic joint" is often caused by injury. A sprain of the ankle, for example, may have been treated by prolonged immobilization, either because the patient had originally impressed the physician with the severity of the symptoms or because of persistent discomfort. When the dressing is removed there may be congestion and discoloration due to impaired circulation, weakness and atrophy of the muscles due simply to disuse, and a certain degree of infiltration and stiffness caused by the original injury. In cases of this character the disability may be prolonged because the patient or the physician mistakes the effects of disuse for the symptoms of serious injury or disease. When the diagnosis has been made treatment should be directed to increasing the activity of the circulation and thus the nutrition of the part, by counter-irritation, by massage, by passive movements, by voluntary exercises and the like, but cure can only be completed by restoring functional use. If, therefore, the disability is of long standing a temporary brace will be required to protect the part from injury, and to increase the patient's confidence. In milder cases it is possible that without support or treatment, other than an assurance of the absence of serious weakness, cure may be accomplished, but this is certainly unusual.

What has been said of exaggerated disability at the ankle following traumatism, applies to the treatment of similar affections elsewhere. The knee-joint is very often the seat of so-called neurosis. Injury at this point in nervous children is often followed by a persistent flexion contraction that may continue for weeks after all signs of the injury have disappeared. When the attempt is made to straighten the knee the patient screams with pain and the muscular resistance is very great. In such cases the immediate rectification of deformity and the application of a plaster bandage to hold the limb in the corrected position is indicated. It must be borne in mind that the persistent assumption of a deformed position for weeks or months must be followed by certain structural changes in the contracted muscles and weakness in the opposing groups. Thus some assistance may be required in the treatment even of the purely hysterical deformities, because of this weakness.

In all forms of traumatic neurosis, so called, the possibility of a physical basis for the symptoms should be considered, the location of the pain or discomfort and its connection with certain movements or attitudes should be investigated. If such discomfort is induced or is aggravated always by a certain motion or attitude it is reasonable to infer that this has a well-defined cause, especially as the pain of a neurotic affection is not often of this definite character. In this class of cases limitation of movement for a time to the painless range of motion by some form of support may be indicated.

Thus far injury has been considered as the starting point of the symptoms, but in many cases there is no history of injury. In this class the symptoms may have been induced by rheumatism or gout or rheumatoid arthritis, or by neuritis and such possible causes should be investigated and excluded before the diagnosis of simple neurosis is made. In neurasthenic patients or those who are anæmic, or overworked, the pain and discomfort is often localized in the spine. The "neurotic spine" has been considered elsewhere. In the treatment of all cases of this group the general condition of the patient should receive consideration, and in connection with the local treatment a change of occupation and of scene is often of advantage.

It is hardly necessary to insist again that an accurate diagnosis is the first essential of successful treatment. If this is impossible, at least one may by exclusion of those injuries and disabilities and diseases which are evidently not present, arrive at a general conclusion as to the character of the ailment, and shape his treatment accordingly.

CHAPTER XIX.

CONGENITAL AND ACQUIRED TORTICOLLIS.

Torticollis.

Synonym.—Wry Neck.

Torticollis is, as the name implies, a twisted neck; a distortion caused in most instances by active contraction or by shortening of one or more of the lateral muscles that control the head. Similar distortion may be due to disease of the spine, so-called false torticollis, but this should be classed as a symptom of the underlying disease, not as simple torticollis of which the distortion itself is the important disability that demands treatment.

Torticollis may be divided primarily into two classes, the congenital and the acquired.

CONGENITAL torticollis is a painless shortening of the tissues on one side of the neck, of intra-uterine origin.

ACQUIRED torticollis is, in most instances, accompanied in its early stages by local pain and sensitiveness, and by active contraction of the affected muscles. After a time these acute symptoms disappear leaving simply the deformity. Thus from the therapeutic standpoint, torticollis may be classified as ACUTE and CHRONIC, the latter class including the congenital form.

The sterno-mastoid is the muscle that is usually involved primarily, both in the congenital and acquired forms; thus in typical torticollis, the head is drawn somewhat forward and is inclined toward the contracted muscle while the chin is slightly elevated and turned toward the opposite shoulder, an attitude explained by the normal action of the affected muscle. Irregular distortions of the head, as posterior or anterior torticollis due to contraction of muscles other than the sterno-mastoid, are however not infrequent. These will be mentioned in the consideration of the forms of acquired torticollis.

Statistics.—Torticollis is comparatively an uncommon deformity. In a period of twenty-seven years 507 cases were treated at the Hospital for Ruptured and Crippled as contrasted with upwards of 5,000 cases of congenital and acquired talipes.

Acquired torticollis is by far the more common variety as is shown by the fact that of the 507 cases but 87 were supposed to be of congenital origin.

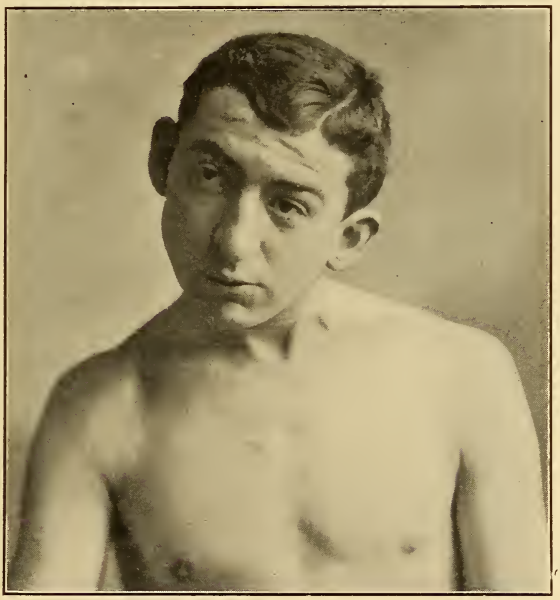
It is often stated that torticollis is more common in males than in females, and that the right side is more often affected, yet 46 of the 87 congenital cases were in females and the contraction was of the left side in 38 of the 58 cases in which the affected side was specified. Of

the entire number of cases available for comparison 246 were in females and 198 in males; in 236 instances the contraction was on the left and in 196 on the right side of the neck. From these statistics it would appear that the deformity is somewhat more common in females than in males and that the left side is more often affected than the right.

Congenital Torticollis.

In most instances the deformity of congenital torticollis is slight at birth and it may not attract attention until the child sits or walks even. Thus it is often difficult to distinguish the congenital form from the deformity that may have been acquired in infancy, especially as the

FIG. 325.



Left torticollis apparently of congenital origin, showing the secondary distortions of head and face.

patient may not be brought for treatment until the distortion has persisted for many years.

In early infancy slight torticollis may be demonstrated by holding the arm on the affected side and drawing the head forcibly in the opposite direction, when the shortened muscle becomes prominent beneath the skin, evidently restricting the range of motion. In most instances the sternal division of the muscle appears to be more shortened than the clavicular portion.

In exceptional cases the deformity even in infancy may be extreme, and it may be accompanied by well-marked asymmetry of the face and even by distortion of the skull. In this class the shortening may in-

volve all the lateral tissues, both anterior and posterior. Slight asymmetry may be present at birth, and in the acquired form it is usually evident soon after the onset of the deformity, becoming more marked with its continuance. Its cause is the constrained attitude, the restriction of normal use and consequently of the blood supply, combined with the tension upon the tissues of the face, as is evidenced by the fact that it becomes less noticeable after the deformity has been corrected.

In the well-marked cases of long standing, whether congenital or acquired, the face is shorter and flatter, the nose and the corner of the

FIG. 326.

Right torticollis, showing the displacement of the head toward the opposite side.

mouth and the eyelids even on the affected side are drawn downward and the skull shows evidence of atrophy and deformity.

Secondary distortions also appear in the trunk in chronic cases. These are rotation of the spine to compensate for the lateral distortion of the head and an increase in the dorsal kyphosis, "round shoulders." Among the minor secondary deformities upward bowing of the clavicle caused by the tension of the contracted muscle may be mentioned. (Fig. 325.)

In the early stage of torticollis the head is tilted and is displaced toward the contracted tissues, but when the deformity is of longer standing the head following the compensatory convexity of the cervical spine appears to be displaced toward the opposite shoulder. (Fig. 326.)

The compensatory deformities that have been indicated are slight in

infancy but they become more marked in later childhood, for in many instances the shortened muscle ceases to grow; thus an original shortening of half an inch, as compared to its fellow may be increased to two or more inches in later years. This fact emphasizes the importance of thorough treatment as soon as may be possible after the distortion is discovered.

As has been stated the important contraction is usually of the sterno-mastoid muscle, but if the deformity is uncorrected all the lateral tissues become shortened, so that at a later stage complete division of the cervical fascia as well as of the muscles may be necessary before the deformity can be corrected.

Typical wry neck caused by shortening of the sterno-mastoid muscle is by far the most common form of congenital torticollis, but occasionally cases are seen in which the head is but slightly inclined to one side and in which the shortening appears to involve the lateral tissues in general rather than a particular muscle. In rare instances, although the deformity resembles that of typical torticollis, the greatest shortening will be found to be of the posterior muscles on one side, particularly of the trapezius and the levator anguli scapulæ. Thus the scapular may be elevated and tilted forward. This form of torticollis appears to be one variety of congenital elevation of the scapula. (See page 185.) Torticollis due to defective development of the upper extremity of the spine is a rare deformity that does not require special description.

Etiology.—It may be assumed, disregarding the possible influence of hereditary predisposition, that congenital torticollis is, in most instances, caused by a constrained or fixed position in the uterus for a longer or shorter time before birth. It is in fact a simple distortion; and that it has, in the majority of cases, no deeper significance is proved by the fact that it may be easily and completely cured by simple division or elongation of the contracted tissues.

It would seem that a deformity to be properly congenital, must be present at birth, yet the theory, first advanced by Stromeyer, that congenital torticollis is the result of injury at birth has been so generally accepted that it merits further consideration.

Hæmatoma of the Sterno-mastoid Muscle.—Hæmatoma is considered to be, and undoubtedly is, evidence of injury. During difficult delivery, fibers of the muscle are ruptured, usually in the upper or middle third of the anterior border, hemorrhage follows, which in turn is surrounded by an encapsulating area of inflammatory material. This forms a firm cylindrical tumor in the substance of the muscle which becomes noticeable two weeks after birth, or at least this is the time when it is usually discovered by the mother. As a rule, the tumor is not sensitive to pressure; it may or may not be accompanied by restriction of motion in the direction causing tension on the muscle. The tumor remains for from three to six months, when it usually disappears, leaving no trace of its presence.

The theory of Stromeyer, which until recently was generally ac-

cepted, is that congenital torticollis is caused by rupture of the muscle and by myositis about the hæmatoma. This inflammation may involve and ultimately destroy a large part of the substance of the muscle replacing it with fibrous tissue, which contracting, causes deformity.

This theory is extremely improbable for the following reasons:

1. Rupture of muscle elsewhere is practically never followed by myositis and contraction.

2. It has been demonstrated by Heller,[1] that it is impossible to cause myositis and contraction by any form of injury to the muscles of animals unless it be combined with actual infection with pyogenic germs.

3. Most of the cases of congenital torticollis seen soon after birth present no evidence of hæmatoma or injury, viz.: In 7 of 55 cases of supposed congenital torticollis investigated by the writer there was a history of injury at birth. In 48 cases no mention was made of injury. In the seven cases referred to the deformity was accompanied by hæmatoma or there was a history of a swelling, apparently of this nature; but in two of these the hæmatoma was coincident with intra-uterine shortening of the muscle.

4. Cases of hæmatoma of the sterno-mastoid muscle are not as a rule followed by torticollis. Seven consecutive cases of hæmatoma were examined by the writer with especial reference to this point. In all the evidence of violence in delivery was clear. Two were delivered by forceps, three were breech presentations and in two version was performed. In one case an arm was broken and in another paralysis resulted from injury to the brachial plexus. Six of the children lived until the swelling had nearly or entirely disappeared and in none did torticollis accompany or follow the hæmatoma.

5. In certain cases a congenitally shortened muscle may be ruptured at delivery; thus the hæmatoma is simply a complication of torticollis, not its cause. Bruns[2] has reported such a case, and two others have been observed by the writer, in one of which club foot was present also.

6. Hard tumors of the sterno-mastoid muscle are not always the result of injury; myositis may be of syphilitic origin apparently occurring in intra-uterine life. In other instances tumors of fibrous or sarcomatous nature have been removed from the substance of the muscle.

Congenital torticollis in the majority of cases is of intra-uterine origin. If it follows injury at birth it is probably an indirect result of local pain, discomfort and irritation of the nerves or of an actual infectious inflammation of the injured part.

Pathology.—In the ordinary type of congenital torticollis, as demonstrated at operations on children, the substance of the affected muscle or muscles is simply lessened in amount and there is a disproportionate

[1] Heller, Deutsche Zeits. f. Chir., Bd. 49, H. 2 and 3, S. 234.
[2] Cent. f. Chir., No. 26, 1891.

area of tendinous substance as compared to the contractile tissue. In other instances, the muscle may be almost entirely replaced by fibrous tissue, or it may be traversed by fibrous bands, or patches of scar-like tissue may be distributed throughout its substance. These changes, considered to be evidences of preëxisting myositis, are probably more common among the acquired than the congenital form and as a rule they are found only in cases of long standing. Secondarily all the lateral tissues of the neck are shortened to correspond to the habitual attitude, and the compensatory curvatures of the spine in time become fixed, so that torticollis may be classed as one of the causes of scoliosis.

Acquired Torticollis.

Acquired torticollis is an affection of early life, at least 80 per cent. of the cases beginning in the first ten years.

As has been stated, congenital torticollis is usually a painless shortening of the muscles, while acquired torticollis is, as a rule, a painful affection secondary to injury or disease of some of the structures of the neck, which causes peripheral irritation of the nerves and active contraction of the neighboring muscles. Thus, as a rule, the number of muscles involved in the deformity is greater than in the congenital form; for example, in the ordinary form of acquired wry neck the trapezius, which receives in part the same nerve supply, is usually involved together with the sterno-mastoid; and irregular forms of distortion caused by contraction of other groups, are not uncommon.

Varieties.—The varieties of acquired torticollis may be classified conveniently as follows:

1. The simple or mechanical form due to scar contraction following destruction of the skin or deeper tissues, as from burns or disease.

2. *Acute torticollis* caused by direct inflammation of the muscle, by injury, by inflammatory affections of the surrounding parts, combined in most instances with irritation of the peripheral nerves, which causes reflex contraction of certain muscles or muscular groups.

3. Spasmodic Torticollis.—A form of convulsive spasm, "a disorder of the cortical centers for rotation of the head." (Walton.)

4. Irregular forms of Torticollis.—Paralytic, ocular, psychical and the like.

The first class, that due to scar contraction, needs only to be mentioned.

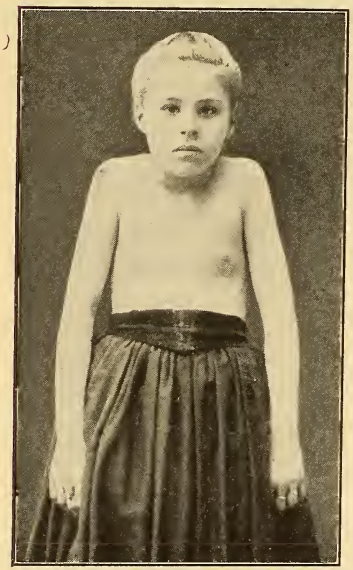
Etiology of Acute Torticollis.—The second class is the most important form of torticollis, both as to frequency and as to its effect in causing permanent distortion. Of this group, one of the most common, and at the same time the least important form, is the simple stiff neck, supposed to be due to cold or to muscular rheumatism. Its onset is, in childhood, sometimes accompanied by slight fever and malaise; the affected muscle is somewhat sensitive to pressure and motion or tension causes discomfort. The distortion, in great part voluntary

and accommodative, is of short duration as a rule. Strains and direct injury of the muscles of the neck may cause deformity, which usually disappears when the local sensitiveness has subsided. Traumatic hæmatomata, similar to those caused by injury at birth, are sometimes observed in older subjects. These usually disappear after a time, leaving no trace of their presence.

Another form of torticollis is secondary to cellulitis and to infiltration following the breaking down of tuberculous cervical glands. This may become a permanent distortion if the deformity is allowed to persist or if the tissues of the neck are injured by the suppurative process.

By far the most important variety of this class is the ACUTE SPASTIC TORTICOLLIS due to active tonic contraction of one or more of the muscles of the neck. The exciting cause of the spasm appears to be irritation of the peripheral nerves in the naso-pharynx or in its neighborhood, and the muscles most often affected are those supplied in part by the spinal accessory nerve. Thus torticollis of this form may follow tonsilitis, pharyngitis, measles, diphtheria and the like. It may be preceded by "toothache" or "earache," or it may be an accompaniment of what appears to be the ordinary form of stiff neck, or of enlarged or suppurating cervical glands. In this form the torticollis is caused directly by tonic contraction of the muscles. Reflex spasm of this character is however often associated with the distortion, due primarily to injury of the neck or to some local inflammatory process, so that a sharp distinction between the divisions of this second class is impossible. Many of the patients are known to be of a nervous temperament and over-study, anxiety, sudden shock and the like are considered to be predisposing causes.

FIG. 327.



Bilateral contraction of the sterno-mastoids and trapezii muscles. (See Fig. 328.)

This variety of acquired torticollis completely overshadows in importance all other forms, as is indicated by the statistics of 212 cases treated at the Hospital for Ruptured and Crippled in which the cause seemed to be apparent. Of the 212 cases 181 may be fairly assigned to this class.

The apparent exciting causes of cases of acquired torticollis treated at the Hospital for Ruptured and Crippled is shown in the following table:

Enlarged cervical glands	14	Furuncle of the neck	1
Suppurating " "	41	Cold in the neck	5
Scarlet fever	14	Rheumatism	18
Diphtheria	7	Vaccinia	1
Mumps	6	Fever	6
Measles	2	Malaria	5
Sore throat	8	Injury to the neck	35
Suppurating otitis	3	Rhachitis	3
Toothache	6	Syphilis	1
Cellulitis of the neck	2	Cicatricial contraction	3
		Total	181

Torticollis associated with chorea	4
" " " epilepsy	1
" " " cortical irritation	5
" " " hysteria	1
" " " meningitis	1
" " " hemiplegia	3
Spasmodic torticollis	8
"Functional torticollis"	8
Total	31

Symptoms of Acute Torticollis.—As a rule the distortion of the neck is slight at first, more noticeable at night than in the morning; it then gradually increases until the deformity becomes fixed. In other instances the onset is sudden, sometimes accompanied by fever.

In most instances several muscles are more or less involved in the contraction, particularly the sterno-mastoid and the trapezius, and in such cases the deformity is more marked and persistent than when the sterno-mastoid is alone affected. Less often the contraction is of the posterior group, "posterior torticollis," when the head is tilted backward and the chin is turned more toward the opposite side than in the typical lateral form. In other cases the contraction appears to affect the small muscles that control the small joints at the upper extremity of the spine when the head may be tilted forward with but slight lateral inclination, resembling closely, except in the history, the symptomatic wry neck of Pott's disease. In rare instances the muscles on both sides of the neck may be contracted simultaneously. (Fig. 327.) The con-

FIG. 328.

Bilateral torticollis after treatment. (See Fig. 327.)

tracted muscles are usually sensitive to manipulation and attempted rectification of the deformity causes extreme pain and is resisted by the patient. The child is as a rule nervous and irritable, it often complains of neuralgic pain about the contracted part which is increased by sudden or unguarded movements or strain; thus "getting the patient to bed" is often a tedious proceeding because of the difficulty of supporting the head comfortably with the pillows.

In many instances the affection is of short duration; in others, particularly those in which the reflex spasm is aggravated by local inflammatory processes, there appears to be but little tendency toward recovery. In such cases, after several weeks or months, the local pain and sensitiveness may subside together with the active spasm, but the deformity remains, caused by actual shortening of the muscles and fascia, aggravated in some instances by the destructive effect of actual myositis. The muscles atrophy and degenerate and present at a later stage the same pathological appearances that are found in the congenital form.

Diagnosis.—Torticollis is most often confounded with **Pott's disease.** This would seem to be hardly possible in cases of the simple painless contraction of chronic torticollis. In the acute form, however, there may be more difficulty in distinguishing between the two. The main points have been mentioned already in connection with Pott's disease. In acute torticollis the affection is of sudden onset, not preceded by the stiffness and neuralgic pain that usually characterize tuberculous disease. The deformity of torticollis is almost always of the regular type, that is, the head is tilted toward the contracted muscles while the chin is rotated in the opposite direction. The spasm and contraction of the affected muscles are very plain and direct tension upon them is painful. If the contraction is relaxed by inclining the head toward the contraction, motion in other directions will be found to be practically unrestricted.

In Pott's disease the spasm of muscles is general, the deformity is not of a regular type, since the chin often points to the side toward which the head is inclined. Steady tension with the aim of reducing the deformity is not as a rule painful; in fact it is often agreeable to the patient. Finally the limitation of motion cannot be lessened by inclining the head toward the muscle that seems to be most contracted, for the reflex spasm of Pott's disease limits motion in every direction. As a rule the diagnosis is easily made, but in cases complicated by suppuration of the cervical glands it is sometimes impossible to exclude Pott's disease until after the effect of treatment has been observed.

Disease of the cervical spine, other than tuberculous, is comparatively rare and resembles in its symptoms Pott's disease rather than torticollis. **Acute arthritis** of the atlo-axoid articulation that may be a complication of rheumatism or that may follow infectious disease is of sudden onset and sometimes resembles in the symptoms and deformity the acute spastic torticollis, except that all the surrounding muscles are affected rather than a particular group; in fact but for

the history it could not be distinguished from tuberculous disease of this region.

Although the diagnosis of torticollis is simple, it is not always easy to determine the muscle or muscles involved in the contraction of the acquired form.

The effect of unilateral contraction of the different muscles is as follows :

The sterno-mastoid inclines the head toward the contraction, elevates the chin and turns it in the opposite direction.

The trapezius has much the same action, but the backward inclination and rotation are more marked.

The action of the complexus resembles that of the trapezius, but the rotation is less.

The splenius inclines the head backward and toward the contracted muscle but does not turn the chin in the opposite direction.

The scaleni have the same action except that the head is inclined forward.

As has been stated, in acute torticollis several muscles are often involved, but the spasm is usually greater in one or in one group than in another. The seat of greatest contraction may be determined by the deformity, by the evident spasm that resists reposition and by the local sensitiveness on palpation. As a rule when the primary contraction is of the posterior group, the deformity is more marked than in other forms. Bilateral contraction of the muscles is rare, but it is occasionally seen. (Fig. 327.)

Treatment.—The treatment varies according to the cause and with the duration of deformity. Excluding, for the present, the rare and irregular forms of wry neck there are, from the remedial standpoint, two forms of torticollis.

1. The chronic form—in which the local pain and sensitiveness are absent, but in which there is resistant and permanent deformity. As has been stated, congenital torticollis is included in this class.

2. The acute form in which the distortion is of short duration and in which permanent contraction may be prevented.

The Treatment of Chronic Torticollis.—Congenital torticollis, if of moderate degree, can be overcome in early infancy by methodical stretching of the contracted parts. One person fixes the arm and another draws the head gently but firmly in the direction opposed to the contraction, over and over again, meanwhile massaging the tissues of the neck. The procedure should be repeated several times a day; it causes slight momentary discomfort if properly performed, but this ceases when the stretching is discontinued. Care should be taken also that the postures may, as far as possible, favor the reduction of the deformity; thus while the child is in the mother's arms the head should be supported, and when asleep the pillow may be arranged in a manner to prevent the improper position. In this way the torticollis may be entirely corrected or its progress may be checked until more effective treatment is indicated.

Hæmatoma.—The evidence of injury at birth should be treated by massage with some bland ointment; if it is accompanied by deformity the manipulation already described should be employed.

In the great majority of cases of congenital torticollis the patient is not brought for treatment until the deformity has become an eyesore to the parents. The contracted muscle is then usually an inch shorter than its fellow, the disparity increasing as a rule with the growth of the child. In such cases the immediate correction of the deformity is indicated, and this implies in most instances division of the contracted parts by subcutaneous tenotomy or by open incision.

If the deformity is comparatively slight and if the contraction seems to be limited to the sterno-mastoid, and particularly to its sternal portion, one may hope to overcome the most resistant part of the contraction by the subcutaneous operation. Aside from the possibility of wound infection, which at the present time is an argument of very little weight, subcutaneous tenotomy has the advantages of simplicity, apparent freedom from the danger which parents associate with an operation, and it leaves no scar behind. It is totally inadequate however for the correction of advanced cases.

Correction of Deformity by Subcutaneous Tenotomy.—The patient and the instruments having been prepared as for an ordinary operation, a sand bag is placed beneath the shoulders and the head is inclined so that the contracted muscle is thrown into relief beneath the skin. The sternal insertion of the tendon is seized with two fingers and the tenotome is inserted beside it and passed beneath it at a point about an inch above the sternum. It is then divided by a sawing motion of the knife. Division of this part of the muscle in this situation is practically free from danger and in the slighter degrees of deformity one can by vigorous manipulation and forcible traction overcome the resistance offered by the other tissues. If bands of fascia resist the correction, they may be divided by superficial nicking with the tenotome in the lateral region of the neck. As a rule, however, in cases of this type the open incision is to be preferred, as it allows the opportunity for free division of the contracted parts with less danger of injury to the blood vessels and nerves in this neighborhood.

The Open Operation.—The incision should be made in the line of the muscle midway between the sternal and clavicular insertion. In the milder cases in childhood, it need be little more than an inch in length. A director may be passed beneath the tendon and on this it may be divided. The clavicular insertion and all bands of fascia that resist the normal range of motion may be divided through the incision.

In cases of very great deformity in the adult some of the posterior and as well as the lateral muscles must be divided. In such instances the contracted parts may be divided at the upper border of the neck through an incision from the mastoid process backward along the lower border of the scalp, the scar being concealed by the hair. It must be borne in mind that the object of the operation is, by means of division and forcible stretching of the contracted parts, to overcome all

restriction to normal motion, and that the failure to accomplish this usually explains the recurrence of deformity, which necessitates the use of apparatus after the operation.

Not only should all resistance be overcome by vigorous manipulation at the time of operation, but the head should be fixed during the process of repair in the over-corrected position. Thus in the treatment of typical torticollis the chin should be turned to a point over the middle of the clavicle on the operated side and the head should be inclined toward the opposite shoulder. In this attitude a plaster bandage should be applied surrounding the head and the thorax. This bandage should remain until all local sensitiveness has disappeared and until the tendency toward deformity has been checked. This fixation in the over-corrected position is very important in childhood, as an aid in overcoming the deformity habit, but it may be dispensed with in the treatment of adults. (Fig. 329.)

Fig. 329.

Torticollis left, showing the method of fixing the head in the over-corrected position. After operation.

The plaster bandage is retained from four to eight weeks; when it is removed, massage, manipulation and gymnastic training are indicated. Twice a day the head should be forced to the extreme limit of over-correction. Traction on the neck in self-suspension by means of the sling used in the application of the plaster jacket, a regular system of exercises for the muscles of the neck and back and supervision of the habitual postures will usually assure a complete cure. If, however, the deformity habit is strong so that the head has a marked tendency to resume the former attitude some support is indicated. A simple and effective support is the jury mast as used in the treatment of Pott's disease with the plaster jacket or attached to a brace. In the treatment of children a band of elastic tape arranged to draw the head toward the shoulder as suggested by Sayre may be sufficient. In the after-treatment of the advanced cases, a support modelled after that of Brown [1] is effective and comparatively inconspicuous.

[1] Bradford and Lovett, p. 588.

As has been stated the necessity for support, provided the deformity has been thoroughly over-corrected, depends upon the care that is to be exercised in the after-treatment. When exercises and massage can be efficiently employed, as a rule the support will not be required. In other cases it may be worn for several months with advantage.

The principles of the treatment of the chronic or painless form of torticollis that have been outlined apply to the acquired, as well as to the congenital form, after the subsidence of the acute symptoms, when passive shortening has replaced active contraction. Acquired torticollis is, in most instances, however, a preventable deformity; thus operative treatment would be rarely required had the patient received proper treatment.

The Treatment of Acute Torticollis.—The insignificant form of torticollis called stiff neck may be treated by hot applications; a firm, thick collar of flexible cotton stiffened by several layers of adhesive plaster is an agreeable support in the more painful cases.

In true acute spastic torticollis the cramp-like contraction of the muscles is secondary to some irritation elsewhere, which one should always try to remove, and, as has been stated, the general condition of the patient may require treatment as well. But the important indication is to support the head and thus to relieve the pain and to prevent permanent distortion. In the early stage the support of the collar that has been described may be sufficient, but as a rule patients of this class are not seen until the distortion has persisted for weeks or months even, so that a more efficient form of support is required—such is the plaster jacket and jury mast. The elastic tension of this appliance overcomes the spasm and relieves the discomfort and apprehension which have lowered the vitality of the patient. If the spasm is the result of the irritation of enlarged or suppurating cervical glands, as is often the case, the rest afforded by the brace is an effective treatment of the cause as well as of its effect, and if suppuration is present this support is most convenient for the dressing that may be required. When the acute symptoms and deformity have been relieved, manipulation and exercises may be employed in the manner already described.

In cases of longer standing, particularly when the posterior muscles are involved, the deformity may be forcibly corrected under anæsthesia and the head may then be fixed in a plaster dressing in the manner already described. This treatment may be employed at an earlier stage in selected cases. As a rule, when deformity has been allowed to persist for six months or more, its rectification will require division of the more resistant tissues.

Spasmodic Torticollis.

Spasmodic torticollis, a form of convulsive spasm of the muscles of the neck that is somewhat similar in its general characteristics to writer's cramp,[1] must not be confounded with the acute torticollis of

[1] Spasmodic torticollis is defined by Walton as a "disorder of the cortical centers for rotation of the head." Am. Jour. Med. Sci., March, 1898.

childhood, in which tonic spasm of the affected muscles, due usually to some well-defined irritation of the peripheral nerves, is the characteristic. Spasmodic torticollis is an affection of adult life. Of 32 cases collected by Richardson and Walton,[1] but two were in patients less than twenty years of age. The sexes are equally liable to the affection and the contraction is as frequent on one side as on the other.

The onset of the affection is usually gradual. The first symptoms are often sensations of stiffness and discomfort in the muscles of the neck; a "drawing sensation" and a momentary twitching or slight contraction which draws the head to one side. These symptoms increase slowly until the head is habitually inclined in the attitude of torticollis. For a time the patient can correct the position voluntarily, or by supporting the head with the hand can restrain the twitching of the muscles, but in well-established cases the head is inclined permanently to one side and the convulsive spasm is uncontrollable. This latter symptom is the most marked peculiarity of the affection; at intervals the head begins to twitch and it is finally drawn by the convulsive contraction of the muscles into an attitude of extreme deformity. As the muscles most often affected are the sterno-mastoid and trapezius the attitude is usually one of typical torticollis. The spasmodic clonic contractions may involve the muscles of the face or of the chest even. They are more marked when the subject is excited or when sudden movements are necessary. As a rule, patients complain of neuralgic pain in the head and neck, aggravated by the cramp-like contractions.

Etiology and Pathology.—The etiology is obscure. Many of the patients present a neurotic family or personal history, and over-work, shock to the nervous system and the like are cited as predisposing causes.

The affection has been compared to writer's cramp as in certain instances the spasm appeared to be caused by constrained positions of the head necessitated by certain occupations, aggravated it may be by the strain of defective eyesight.

The affected muscles may be hypertrophied from constant activity, and in the later stages of the affection they are, as a rule, permanently shortened. No characteristic changes in the nerves or in the central nervous system have been recorded.

Prognosis.—There is little tendency toward spontaneous recovery. As a rule the spasm becomes more constant and other muscles become involved.

Treatment.—It is perhaps unnecessary to state that the general condition of the patient and the possible local and general causes of the spasm should receive consideration. As a rule, however, the patient will have exhausted both constitutional and local treatment before coming under observation.

In the mild and early cases the avoidance of predisposing causes combined with massage, systematic muscle training and in exceptional

[1] Am. Jour. Med. Sci., Jan., 1895.

instances mechanical support may be of service, but in the chronic, severe and persistent cases of this class the resection of nerves supplying the affected muscles has alone proved to be efficient. If the spasm is limited to the sterno-mastoid and trapezius muscles resection of the spinal accessory nerve may be sufficient; but if other muscles are involved or if the spasm recurs after the original operation, the removal of the posterior branches of the upper cervical nerves together with extensive division of the contracted muscles upon the same side and sometimes upon the opposite side also, may be required.

Resection of the spinal accessory nerve was first performed by Campbell de Morgan, of London, in 1866, and since then the operation has been repeated many times by other surgeons with temporary or permanent benefit to the patients. According to Pétit of 26 patients so treated 13 were cured and 7 were permanently improved. In five others the benefit was but temporary, one died from erysipelas following the operation.[1]

The Operation.—The spinal accessory nerve passes downward and backward from the jugular foramen and enters the anterior border of the sterno-mastoid muscle at a point about one and a-half inches below the tip of the mastoid process. At this point it should be exposed. Dr. E. Eliot, Jr., from a special study of the course and relations of the nerve, suggests the following method:[2]

"The incision should be generous, for the nerve is situated at a considerable depth, and should extend from the mastoid process above, downward to one or two inches beyond the angle of the jaw. The anterior edge of the sterno-mastoid should then be exposed. In the upper part of the wound, the posterior and inferior portion of the parotid gland may have to be drawn forward, although usually it does not overlap the muscle. When this is done, it is comparatively easy to expose by blunt dissection the transverse process of the atlas, as it lies directly below the mastoid process above, while immediately in front of this bony prominence, and running downward and forward from the mastoid process toward the angle of the jaw, is the posterior belly of the digastric. Behind this lie the main vessels of the neck with the spinal accessory nerve emerging from the jugular foramen and the operator is certain that no harm can be done to these structures as long as he remains superficial to the digastric belly, which in its turn lies at a considerable depth—in fact, at about the level of the transverse process of the atlas.

"Owen and Pétit have drawn attention to the fact that the nerve usually enters the mastoid muscle at a point opposite the angle of the jaw. I have found, however, in a large majority of cases, that on leaving the internal jugular it assumes a definite relationship with the transverse process of the atlas. Never above it, sometimes directly over it, usually a fraction of an inch in front of its most prominent part, the nerve may easily be detected in the small amount of connective tissue that envelops it, and from this point to its entrance into

[1] L'Union Médicale, July 9, 1897. [2] Annals of Surgery, May, 1895.

the belly of the muscle it may be isolated with safety, and treated by any suitable procedure. If, exceptionally, it should escape detection, the anterior border of the muscle should be drawn sharply backward at a point opposite the angle of the jaw, the nerve in this way put on the stretch, and by blunt dissection in the adipose tissue that separates the under surface of the muscle from the sheath of the vessels, the nerve may readily be exposed. Usually the nerve passes from under the posterior belly of the digastric, at a point just in front of the transverse process of the atlas, to a point on the deep surface of the muscle just behind its anterior margin opposite the angle of the inferior maxilla. It is sometimes accompanied by a small artery and vein, the latter easily visible, the former a branch of the occipital. Rarely the nerve lies at a considerable distance from the transverse process of the atlas; in one case as much as half an inch anteriorly. Here the nerve could be found at its entrance into the muscle, the landmark of the transverse process having failed to localize its situation."

Richardson suggests that if the nerve is not readily found, its position may be ascertained by drawing the finger nail firmly across the bottom of the wound, a sharp contraction following pressure upon it. The nerve having been isolated a section of an inch should be removed. Richardson advises in addition vigorous stretching of both extremities. After division of the nerve the spasmodic contraction relaxes and the muscles become flaccid, allowing the head to be brought to the normal position, or if the deformity has become permanent the contracted parts may be divided as in the ordinary form. Fixation of the head is not, as a rule, required. The operation should be supplemented by massage and by muscle training. If the spasm has been confined to the muscles supplied by the spinal accessory nerve, the treatment may be permanently successful, but in many instances the spasm may recur in other muscles. Of these, the posterior group of the opposite side is more often affected and a similar operation for resection of the posterior branches of the upper cervical nerves may be indicated. This has been performed with success by Smith of London, Keen, Richardson and others. According to Smith[1] the operation should be conducted as follows: an incision is carried downward from the occiput about three inches in length, parallel to and one inch from the spinous processes. It is continued through the trapezius to the edge of the splenius. The complexus is then divided and the posterior branches of the nerves are exposed; those of the three upper nerves which supply the posterior rotators are then resected.

Keen[2] operates in a somewhat different manner, by a transverse incision two and a-half inches in length from the middle line of the neck on a level with a point one-half an inch below the level of the lobule of the ear. The trapezius is divided transversely, afterwards the complexus, care being taken to spare the great occipital nerve. The posterior branch of the second cervical nerve is then resected, the sub-occipital nerve is then looked for in the sub-occipital triangle

[1] Spasmodic Wry Neck, London, 1891. [2] Annals of Surgery, January, 1891.

traced down to the spine and divided. The external trunk of the posterior division of the third occipital nerve is then exposed below the great occipital and divided close to the bifurcation of the nerve trunk, thus the nerve supply of the chief posterior rotators, the splenius capitis, the rectus capitis, posticus major and the obliquus inferior is removed.

The paralysis that follows even such extensive operations seems to inconvenience the patient but slightly, while the relief from deformity and from the constant spasm is a more than sufficient compensation for whatever weakness or disability may result.

The following are the conclusions of Richardson and Walton:[1]

1. Palliative treatment, whether by drugs, apparatus or electricity, will rarely prove successful in well-established spasmodic torticollis.

2. Massage may prove of value in comparatively recent cases.

3. Resection affords practically the only rational remedy.

4. Operation on the spinal accessory nerve may afford relief, even if other muscles than the sterno-cleido-mastoid are affected; on the other hand the affection previously limited to the sterno-cleido-mastoid may spread to other muscles in spite of this operation.

5. No fear of disabling paralysis need deter us from recommending operation, as the head can be held erect even after the most extensive resection.

6. The most common combination of spasm is that involving the sterno-mastoid on one side and the posterior rotators on the other, the head being held in the position of sterno-mastoid spasm with the addition of retraction through the greater power of the posterior rotators.

7. It seems advisable in most cases to give preference to the resection of the spinal accessory as the preliminary procedure.

In a later communication Richardson and Walton[2] report very satisfactory final results on cases treated by resection of nerves supplying the muscles that were affected by the spasm on one or both sides, combined with complete division of the muscles as well, when permanent contraction was present.

Kalmus[3] has reviewed the literature of the subject. In eleven cases of simple stretching of the spinal accessory nerve, three were cured. In sixty-eight cases the nerve was resected; of these twenty-three were cured and twenty were improved. In four there was no improvement and in one the patient died. In fifteen cases the resection of the nerve was supplemented by division of cervical nerves; ten of these were cured and three were improved. In two others the sterno-mastoid muscle was divided.

IRREGULAR AND EXCEPTIONAL FORMS OF TORTICOLLIS.

Paralytic Torticollis.

One or more of the muscles of the neck may be paralyzed as from anterior poliomyelitis and thus a deformity, due at first to simple weak-

[1] Annals of Surgery, January, 1891.

[2] Am. Jour. Med. Sci., July, 1896.

[3] Zur Operativ Behand. Caput. Obst. Spasticum, Beiträge zur Klin. Chir., Bd. 26, 1900.

ness, and later to the permanent effects of the disability may be the result.

Diphtheritic Paralysis and Torticollis.

The muscles of the neck may be involved in paralysis following diphtheria. In this form the trapezii muscles are as a rule involved so that the head hangs forward, but occasionally the paralysis may be accompanied by contraction of one of the sterno-mastoids. The history, the evident weakness, and the paralysis of the soft palate or other parts, which is often present, usually make the diagnosis clear.

Cervical Opisthotonos.

In the course of certain forms of disease of the nervous system, for example cerebro-spinal or basilar meningitis, the head may be drawn backward by spasm of the posterior muscles. A slight degree of the same deformity is sometimes seen in ill-nourished infants not suffering from serious disease. This and the preceding distortion are of some importance because they may be mistaken for symptoms of Pott's disease and they have been described in that connection. (See page 55.)

Rhachitic Torticollis.

During the course of acute rhachitis, particularly when the characteristic deformity of the lower part of the spine is well marked, the head may be tilted backward usually as a compensatory attitude, but occasionally slight spasm of the posterior muscles may increase the distortion; so also when lateral deviation of the spine is present due to rhachitis, the neck may participate in the deformity as in other forms of rotary lateral curvature. This is not torticollis, however, in the proper sense.

Ocular Torticollis.

Several cases have been recorded in which the head was habitually held in a distorted attitude because of defective vision or irregularity in the action of the muscles of the eyes. This is, however, rather an improper attitude than a variety of true torticollis.[1] (Fig. 143.)

Psychical Torticollis.

A distortion of the head, apparently due to the inability of the patient to control the muscles of the neck has been described by Brissaud.[2] The deformity was not due to muscular spasm since it could be corrected by the pressure of a finger on the head. The condition is called by Brissaud a local paralysis of the will, a form of neurosis allied to neurasthenia, epilepsy, and functional spasm.

[1] Hobby, Med. News, June 11, 1898, p. 772.
[2] Thèse de Paris, 1894.

CHAPTER XX.

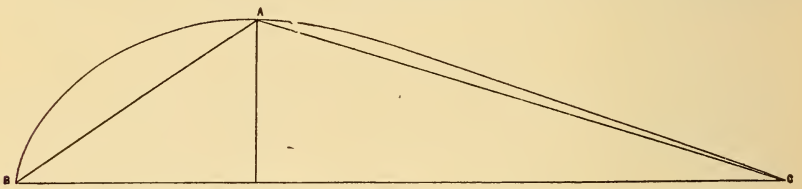
DISABILITIES AND DEFORMITIES OF THE FOOT.

General Description of the Foot and of Its Functions.

THE function of the foot is two-fold: to serve as a passive support of the weight of the body, and as an active lever to raise and propel it. For the proper performance of these functions, the foot is constructed to allow elasticity under pressure, and an alternation of attitudes under strain, that protect it from injury.

The Arches.—The most noticeable peculiarity of the foot is the arrangement of its arches. As has been suggested by Ellis and others,

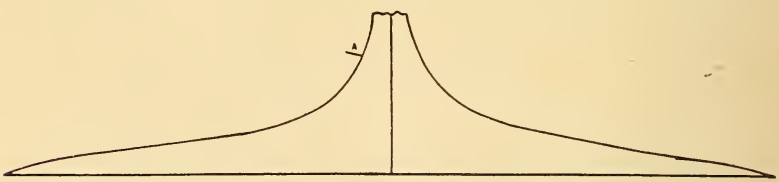
FIG. 330.



Longitudinal section of the cast of the arch at the point A in Fig. 331; A, the astragalo-scaphoid junction; B, the internal tuberosity of the os calcis; C, the head of the first metatarsal bone.

the construction and shape of the arched part of the foot may be better understood by considering it as half of the arch formed by the two feet. This complete arch may be demonstrated by making an imprint of the apposed feet in plaster of Paris. The plaster cast which represents it will appear in shape somewhat like an inverted saucer, the

FIG. 331.

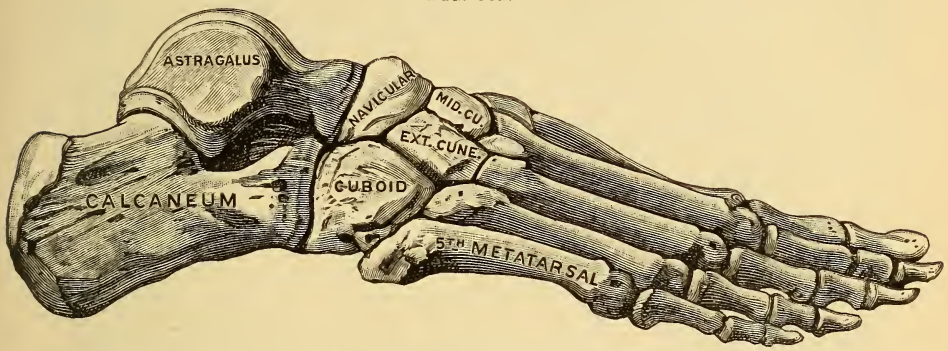


Cross section of the cast of the arches of the apposed feet. A. The internal and inferior angle of the astragalo-scaphoid junction.

part of each foot that rests upon the ground forming half of an irregular ring. If the plaster cast is sawed into equal sections, it will be seen that the highest or thickest part of each division is at the astragalo-scaphoid junction; from this point the arch descends sharply to the

tuberosities of the os calcis and gradually to the outer border, beneath the cuboid bone, and to the metatarso-phalangeal joints. (Fig. 330.) A cross section of the cast will show the contour of what is sometimes called the TRANSVERSE ARCH (Fig. 331), while the section through the long diameter will demonstrate the shape of the LONGITUDINAL ARCH. In descriptions of the longitudinal arch, it is often divided into two parts,

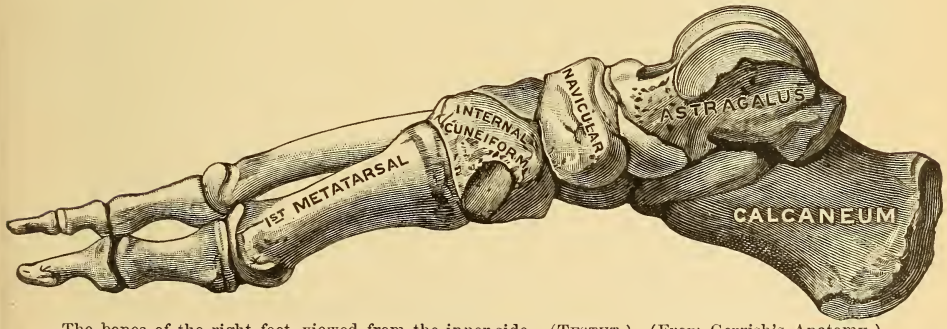
FIG. 332.



The bones of the right foot, viewed from the outer side. (TESTUT.) (From Gerrish's Anatomy.)

of which the outer division is formed by the os calcis, the cuboid, and the two outer metatarsal bones. Of this outer arch, the highest point is at the calcaneo-cuboid articulation (Fig. 332), and although it is normally a permanent arch yet the soft tissues are forced downward beneath it when weight is borne, so that the outer border of the foot makes an imprint throughout its entire length, as contrasted with the

FIG. 333.



The bones of the right foot, viewed from the inner side. (TESTUT.) (From Gerrish's Anatomy.)

inner and deeper arch formed by the os calcis, the astragalus, the scaphoid, the cuneiform and the three inner metatarsal bones. (Fig. 333.) This division, although an artificial one, is of some service in calling attention to the fact that the outer or lower arch is more solidly braced and therefore better adapted to continuous weight-bearing than is the higher and more elastic inner arch.

The diagram of the longitudinal arch, showing its sharp descent from the highest point to the center of the heel, demonstrates the fact that the heel is well adapted for weight-bearing, while the long anterior pillar composed of several bones is less strong but more elastic; thus one instinctively extends the foot in descending stairs, for example, to avoid the unpleasant jar of direct shock received upon the heel. Of this anterior pillar, the third metatarsal bone is the most direct support, while the more movable first and fifth metatarsals, more under muscular control, aid in balancing the weight upon the center of the foot.

Both divisions of the longitudinal arch are permanent arches, but there are two others which are obliterated under weight; one of these is that formed by the heads of the metatarsal bones, the ANTERIOR METATARSAL ARCH. In the unweighted foot, the second and third metatarsal bones occupy a higher plane than their fellows, but when the erect posture is assumed, the anterior arch is depressed to allow all the metatarsal heads to bear their share of the weight. The other arch does not rest upon the ground but is formed by the internal border of the foot, which curves slightly outward, so that when the two feet are placed side by side an interval remains between them, widest at the highest point of the longitudinal arch, as is shown in the diagram by the upright section which divides the cast of the two soles from one another, the INTERNAL ARCH. (Fig. 331.) When weight is borne, this curved contour of the foot becomes straighter, or obliterated or even transformed to an arch whose convexity is internal. (Figs. 351, 352.)

The Foot as a Passive Support.—The foot is supported by the muscles, by ligaments, and by the strong plantar fascia that covers in the sole. When the foot is actively used, it is in great part supported by the muscles, but when it serves as a passive support, as in standing, the ligaments bear the greater part of the strain, and its normal elasticity allows the bearing surface to expand slightly as the arches are slightly depressed. If this normal elasticity is diminished, as is sometimes the case, the supports of the arch are subjected to abnormal pressure and the individual may suffer from sensitive corns or calloused skin beneath the bones. Or if the ligaments allow abnormal expansion, the arches may become permanently depressed and as a result the range of motion necessary to the proper functional use of the foot, may be permanently restricted.

When the statement is made that the foot broadens and that the arches are slightly depressed under weight, it must not be understood that the longitudinal arch is simply flattened by direct pressure and by elongation of elastic ligaments and fascia. Ligaments and fascia are not elastic in this sense and they are not, in the normal foot, overstretched. The change in contour is the effect of normal motion in the joints of the foot, by which it is placed in the most favorable attitude for weight-bearing without muscular exertion—the so-called attitude of rest.

Of the changes of contour that distinguish the foot used as a passive support from the one that bears no weight, the most significant is the obliteration of the outward curve of its internal border. This change is due to the fact that the astragalus, bearing the leg, rotates inward and downward on the os calcis until it is checked by the resistance of the ligaments and by the interlocking of the bones. The head of the astragalus thus becomes slightly prominent, the inner border of the foot is depressed, and an attitude is attained in which the weight of the body may be supported with but slight muscular exertion. In this attitude of rest, as Von Meyer has explained, there is general fixation of joints of the lower extremity which makes support possible with the least muscular exertion. The pelvis tilts slightly upward until tension is brought upon the anterior part of the capsule of the hip joint, the femur rotates slightly inward, so that the tibia is turned outward in its relation to it, and finally the tibia in turn falls slightly inward upon the everted foot. To unlock the joints the pelvis must be tilted forward or the hip must be flexed.

The Foot in Activity.—The second function of the foot is as a lever to raise and to propel the body. The calf muscles supply the power and the heads of the metatarsal bones serve as the fulcrum on which the weight is to be lifted. When the foot is used as a lever, it should be held in such relation to the leg that the line of weight, passing downward through the center of the knee and ankle joints, is continued over the second toe or practically the center of the foot. As the body is lifted over the fulcrum the forefoot is turned inward in its relation to the leg or, more properly speaking, the leg is turned outward because the inner side of the fulcrum, formed by the first metatarsal bone, is longer than its outer side, thus the strain is directed toward the outer and stronger side of the foot. (Fig. 334.)

In the proper walk, which is the best illustration of the leverage function, the feet should be held practically parallel to one another, so that the line of strain may fall through the center of the foot. As one foot is advanced it first bears weight momentarily on the heel, then upon its outer border; the heel is then raised and the body is lifted over the toes, the great toe giving the final impulse to the step, so that if the walker is looked at from behind, he appears to be in-toeing at the termination of each step. Thus, during the walk, there is an alternation of postures, and the foot, under muscular control, assumes the attitudes most opposed to that of passive support.

Improper Postures.—The alternation of postures and the leverage action of the foot are by no means necessary to simple progression; for example, both feet might be fixed in plaster bandages yet walking would be possible, just as it is possible on two wooden legs. Indeed, an approximation to such a manner of walking is often seen, in which the feet are practically held in the passive attitude, the weight being borne upon the heels. Such a walk is necessarily jarring and ungraceful, and if it is not the result of weakness and deformity it predisposes to them because of the disuse of the proper function of the foot.

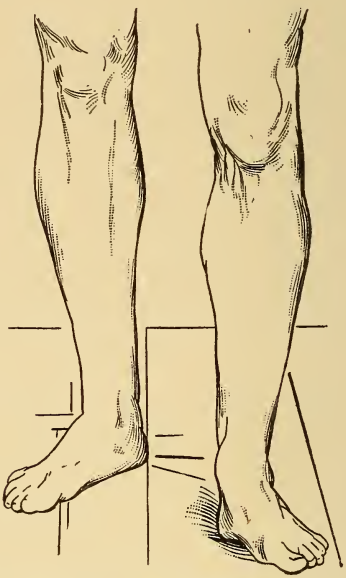
One means of making the leverage function difficult is the custom of turning the feet outward. Outward rotation of the feet is normal in the passive attitude of weight-bearing, because it enlarges the base of support, locks the joints and throws the strain upon the ligaments to relieve the muscles. On this very account it is the improper attitude for activity because the strain falls upon the inner border of the foot, or to the inner side of the fulcrum, and makes the proper exercise of muscular power and alternation of postures impossible. In other words the attitude normal when the foot is used as a passive support is abnormal when it is in active use.

The Movements of the Foot.—The junction between the foot and

FIG. 334.

Illustrates the involuntary adduction of the forefoot, due to the obliquity of the metatarsus, in the proper attitude for walking.

FIG. 335.



The improper attitude of outward rotation in which there is disuse of the leverage function.

the leg is made by means of the astragalus, a bone which is not intimately connected with either part, since it moves upon the leg and upon the foot, and to it no muscles are attached.

The movements of the foot are four in number: Dorsal flexion; plantar flexion; adduction; abduction.

Simple dorsal and plantar flexion are confined to the ankle joint, but complete plantar flexion is combined with slight adduction, and dorsal flexion with abduction, because the external facet of the astragalus allows a greater range of motion on the external malleolus than is permitted about the internal malleolus.

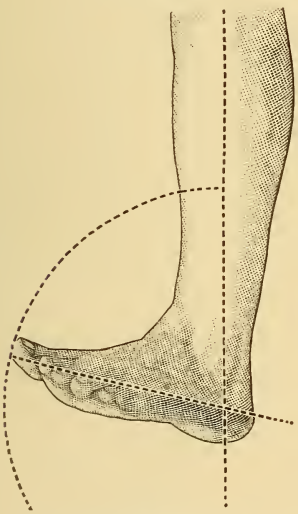
The range of motion at the ankle joint is from sixty to eighty degrees; thus dorsal flexion to ten or twenty degrees less than the right

angle, and plantar flexion fifty to sixty degrees more than the right angle. (Figs. 336, 337.)

Adduction and abduction of the foot are carried out in the medio-tarsal and sub-astragaloid joints.

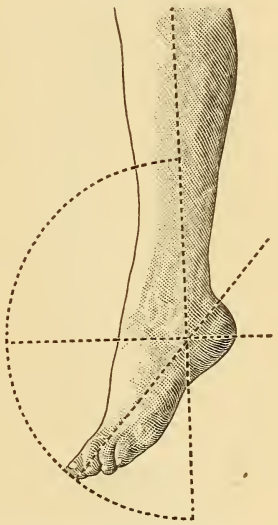
Adduction, the motion of turning the foot inward in its relation to the leg, is always accompanied by inversion of the sole or supination, because of the shape of the joint surfaces between the astragalus and os calcis, where the greater part of the motion takes place. Simple adduction and abduction without supination or pronation is possible to a very limited extent in the medio-tarsal joint. Its range may be tested by fixing the heel, when the forefoot may be moved slightly back and forth upon the astragalus and os calcis. The range of motion in the sub-astragaloid joint is twice as free as in the medio-tarsal

FIG. 336.



Voluntary dorsal flexion.

FIG. 337.



Voluntary plantar flexion.

In these attitudes the astragalus moves with the foot upon the leg bones, as contrasted with adduction and abduction in which the center of motion is below the astragalus.

joint. The character of the motion between the astragalus and os calcis is rotation on an axis passing through the upper and inner part of the head of the astragalus, downward and outward to the outer tuberosity of the os calcis. Thus for all practical purposes, adduction, inversion and supination are synonymous terms: the same is true of abduction, pronation and eversion. Outward rotation is, however, quite distinct, since the center of motion is at the hip joint.

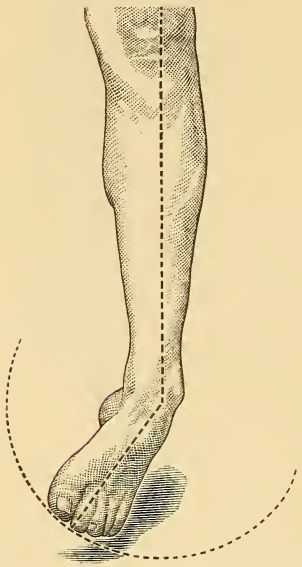
In the movement of adduction of the foot, the astragalus is fixed between the malleoli, and upon it the os calcis glides forward and its anterior extremity turns slightly inward; the sustentaculum tali moves backward, its inner superior surface is elevated and its external surface is depressed. Meanwhile the forefoot, following the motion of

the os calcis, is carried inward about the head of the astragalus; its inner border is elevated and its outer border is depressed, so that the sole looks inward and downward. In this attitude all the arches are ncreased in depth. (Fig. 338.)

In abduction the bones move upon one another in the reverse direction, the curves are lessened and that of the inner border is obliterated. (Fig. 339.)

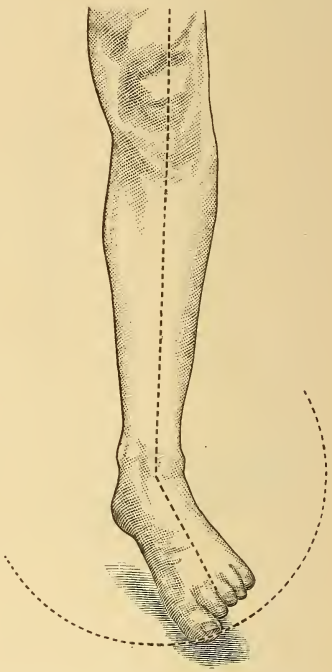
The extreme of adduction is only possible in the position of plantar flexion, because in this position the adduction possible at the ankle joint, in part due to the contour of the astragalus and in part to the

FIG. 338.



Voluntary adduction.

FIG. 339.



Voluntary abduction.

In these postures the foot moves upon the astragalus which is practically fixed between the malleoli. Adduction, the turning of the foot inward in its relation to the leg, is always accompanied by elevation of its inner and depression of its outer border. This is known as supination or inversion of the foot. The reverse of this attitude—pronation or eversion—is an accompaniment of abduction as is illustrated in the figures.

greater mobility allowed in the joint when the narrow posterior border of the astragalus is alone in contact with the malleoli, is added to the adduction which the joints of the foot permit.

Extreme abduction is attained in the attitude of dorsi-flexion, its extent being about one-half that of adduction; the entire range of motion between the two extremes being about forty-five degrees.

In this description the foot is considered as moving on the leg, but in the attitude of rest the foot becomes the fixed point and the astragalus moves upon the os calcis in the manner and to the position

already mentioned in the description of abduction, *i. e.*, it slips downward and forward and turns inward, and at the same time the anterior extremity of the os calcis turns slightly inward and downward, and

Fig. 340.

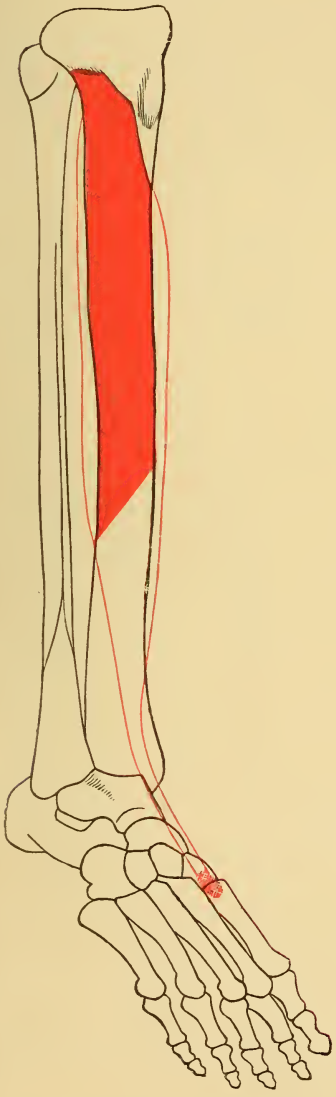


Fig. 341.

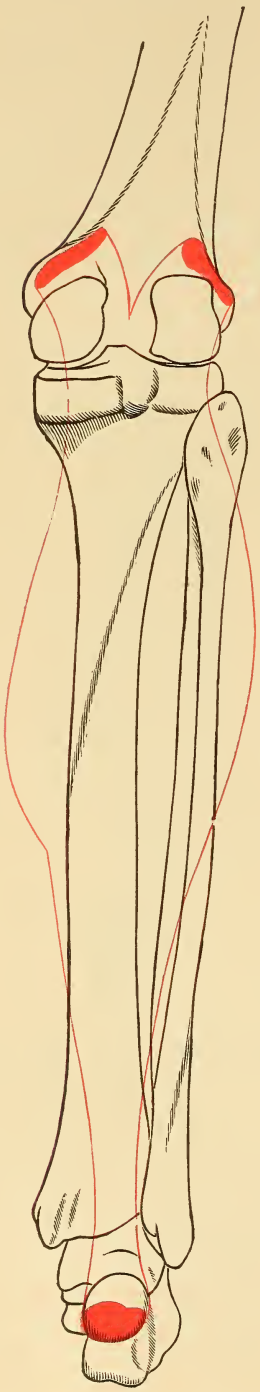
The direct dorsal flexors.

Tibialis anterior of right side: outline and attachment-areas. (Gerrish.)

Peroneus tertius of right side: outline and attachment-areas. (Gerrish.)

its inner border is depressed. Corresponding to this movement, as the inner border of the foot becomes straight or bulges inward, the scaphoid is forced forward and downward and the longitudinal arch is depressed.

Fig. 342.



The calf muscle.
Gastrocnemius of right side: outline and attachment-areas. (GERRISH.)

Fig. 343.

The plantar flexor.
Soleus of right side: outline and attachment-areas. (GERRISH.)

As has been mentioned the turning of the leg inward and the corresponding turning of the foot outward in its relation to it, locks in a manner the ankle joint and at the same time throws the strain upon

Fig. 344.

Peroneus longus of right side: outline and attachment-areas. (Gerrish.)

Fig. 345.

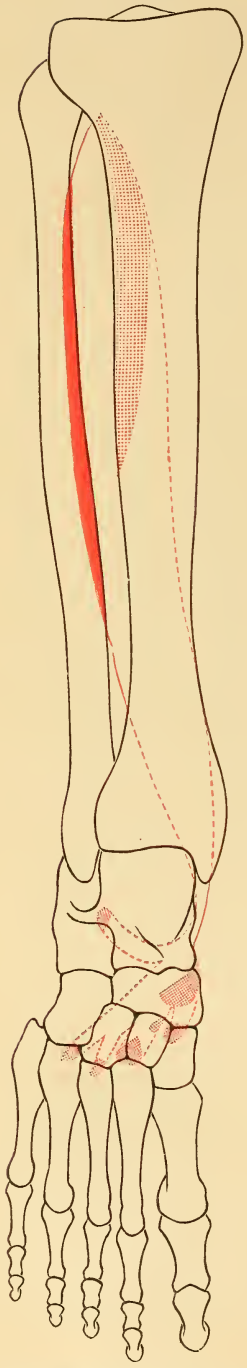
Peroneus brevis of right side: outline and attachment-areas. (Gerrish.)

The direct abductors.

the ligaments, so that standing in the erect posture is possible with but little muscular exertion. (Fig. 351.)

To put it in a simpler manner, the leg supporting the weight of the

Fig. 346.



The most important adductor. Tibialis posterior of right side: outline and attachment-areas. The most of the muscle is represented as if seen through the bones. (Gerrish.)

body has a tendency to tilt the foot over toward the inner side and to evert the sole; thus, under increasing superincumbent weight, the point of greatest pressure on the sole shifts from its center and outer border toward the inner border. If on the other hand the body is raised upon the toes, the arch is relieved from strain and the weight falls upon the front and outer part of the foot. Plantar flexion and adduction represent, as contrasted with the passive attitude of supporting weight, the attitude of activity in which the foot is supported and controlled by the muscles.

The Function of the Muscles.—The most important function of the dorsal flexors is to lift the foot as it is swung forward, while the plantar flexors serve in the active propulsion of the body. The difference in function is shown by the relative strength of the two groups, the plantar flexors being five times the stronger; in fact, the calf muscle (gastrocnemius and soleus) alone is three times as strong as all the other muscles of the foot combined. It is practically the leverage muscle, the others serving more especially to fix and to hold the forefoot, or fulcrum, in its proper relation to the leg. (Figs. 342, 343.)

The muscles that most directly support the inner arch of the foot are the tibialis posticus and anticus, whose tendons meet in their insertion in front of the astragalus in the form of a V. The tibialis anticus supports the internal border of the foot from above, and the posticus is the most powerful adductor. (Figs. 340, 346.)

The flexor longus pollicis, passing directly beneath the sustentaculum tali, aids in supporting the weak part of the foot and its position demonstrates the importance of the proper functional use of the great toe. (Fig. 350.)

The peroneus longus and brevis support the outer arch and the former binds the foot together and holds the great toe firmly against the ground, thus it indirectly supports the longitudinal arch against direct pressure. (Figs. 344, 345.)

The relative strength of the muscles and their functions is shown in the following tables:[1]

DORSAL FLEXORS OF THE FOOT: STRENGTH RECKONED IN KILOGRAMMETERS.

Tibialis Anticus	0.871
Extensor Longus Digitorum	0.280
Extensor Longus Pollicis	0.155
Peroneus Tertius	0.087
	1.393

PLANTAR FLEXORS.

The calf muscle	Soleus	3.256
	Gastrocnemius	2.831
	Flexor Longus Pollicis	0.218
	Peroneus Longus	0.118
	Tibialis Posticus	0.094
	Flexor Longus Digitorum	0.078
	Peroneus Brevis	0.055
		6.650

RELATIVE STRENGTH OF THE SUPINATORS OF THE SUB-ASTRAGALOID JOINT.

	Strength.	Weight of the Muscles.
Soleus	1.021	157.0 Grammes.
Gastrocnemius	0.709	120.0 "
Tibialis Posticus	0.337	39.6 "
Flexor Longus Pollicis	0.172	33.2 "
Flexor Longus Digitorum	0.123	12.3 "
	2.362	362.1 "

RELATIVE STRENGTH OF THE PRONATORS OF THE SUB-ASTRAGALOID JOINT.

	Strength.	Weight of the Muscles.
Peroneus Longus	0.282	24.0 Grammes.
Peroneus Brevis	0.192	16.5 "
Extensor Longus Digitorum	0.164	18.2 "
Peroneus Tertius	0.067	3.5 "
Extensor Longus Pollicis	0.045	12.3 "
Tibialis Anticus	0.021	49.2 "
	0.771	123.7 "

RELATIVE STRENGTH OF THE SUPINATORS OF THE MEDIO-TARSAL JOINT.

Tibialis Anticus	0.238
Tibialis Posticus	0.078
Flexor Longus Pollicis	0.034
Flexor Longus Digitorum	0.033
Extensor Longus Pollicis	0.030
	0.413

RELATIVE STRENGTH OF THE PRONATORS OF THE MEDIO-TARSAL JOINT.

Peroneus Longus	0.162
Peroneus Brevis	0.090
Extensor Longus Digitorum	0.085
Peroneus Tertius	0.033
	0 370

It will be noticed that the strength of the pronators and supinators

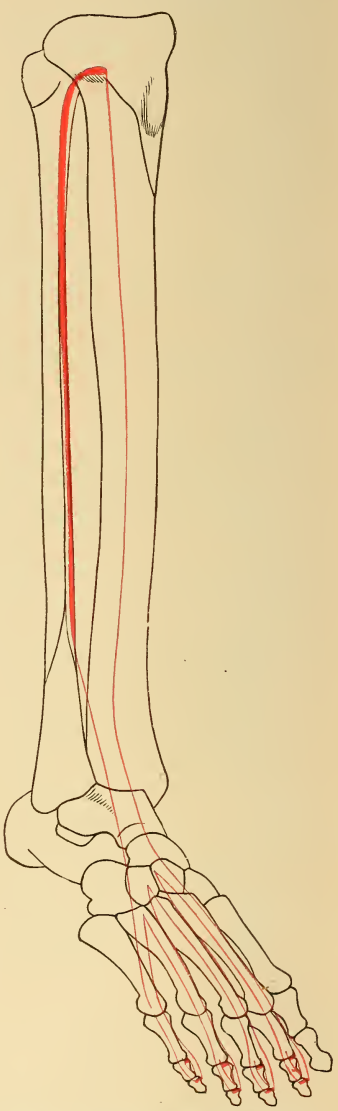
[1] Über die Arbeitsleistung der auf die Fussgelenke Wirkenden Muskeln, R. Fick Leipsic, 1892.

(abductors and adductors) of the medio-tarsal joint is nearly equal, and that the great preponderance of power of the supinators of the sub-astragaloid joint is owing to the fact that the calf muscle is a

Fig. 347.

Extensor proprius hallucis of right side: outline and attachment-areas. (Gerrish.)

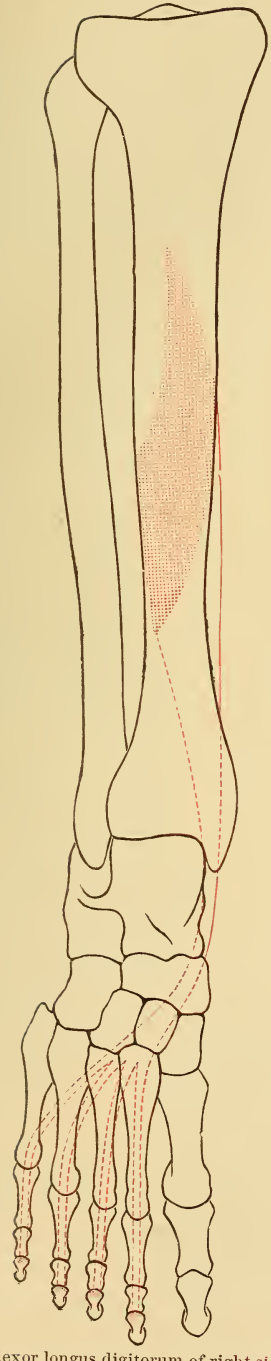
Fig. 348.



Extensor longus digitorum of right side: outline and attachment-areas. (Gerrish.)

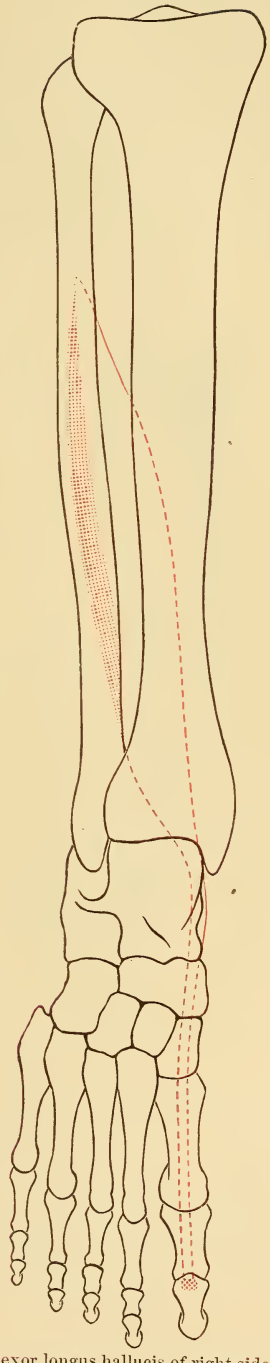
supinator. When the foot is at a right angle with the leg, the power of the calf muscle not being utilized, the pronators are stronger than the supinators. It will be noticed also, that the tibialis anticus muscle,

FIG. 349.



Flexor longus digitorum of right side: outline and attachment-areas. The muscle is represented as seen from in front through the bones. (GERRISH.)

FIG. 350.

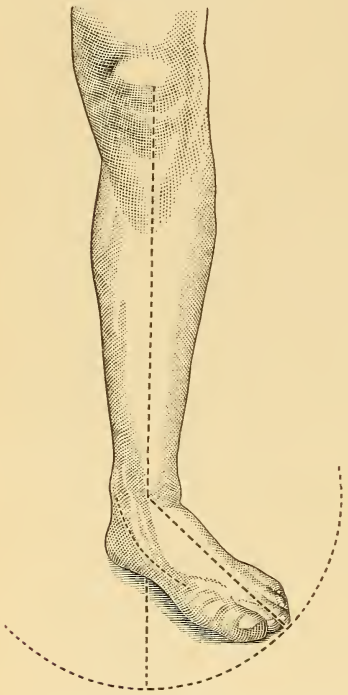


Flexor longus hallucis of right side: outline and attachment-areas. The muscle is represented as seen from the front through the bones. (GERRISH.)

which supinates the medio-tarsal joint, is reckoned among the pronators of the sub-astragaloid joint.

The Foot Considered as a Mechanism.—In the study of the deformities, and particularly of the functional weaknesses of the foot, one must never lose sight of the fact that it is a machine, subject to the same mechanical laws that govern other machines, and that its deformities and disabilities, its relative strength or weakness, may be appreciated by comparing it with the normal standard. As in other machines, marked deformity or distortion is evident at a glance, even

FIG. 351.



An attitude that simulates flat foot. (See Fig. 353.)

FIG. 352.

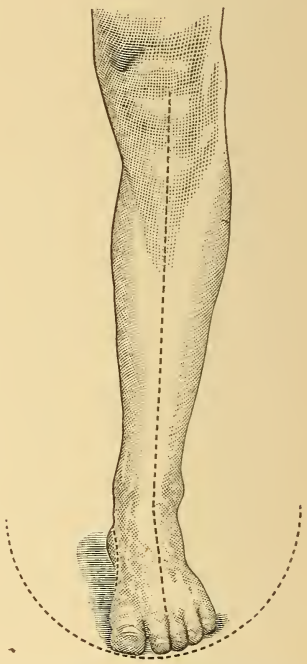


Fig. 352, compared with Fig. 351, will illustrate the voluntary protection of the foot from over-strain.

though the apparatus is not in use, but functional ability can be judged only by the manner in which active work is performed.

As has been stated, the foot is, in activity, a lever, by means of which the weight of the body is lifted and propelled. If it is loosely constructed or insufficiently supported by the ligaments, it is evident that it can not be properly controlled by the muscles. If, on the other hand, the muscular power is insufficient, it is evident also that the weight of the body can not be lifted and properly balanced upon it. The structure of the foot may be normal and its muscles may be of normal strength yet the strain placed upon it may be disproportionately

great. This strain may be actual over-weight, or the over-work of a laborious occupation, but more often the machine is over-worked simply because it is subjected to mechanical disadvantages in the performance of its functions, by the assumption of improper attitudes.

An improper attitude is one that limits or lessens the range of motion, and the alternation of postures, that protect the foot from over-strain. One of the most common of such attitudes is, as has been mentioned, that of turning the feet outward in walking, thus the fulcrum being displaced outward, the strain falls through the inner and weaker side of the foot. As a consequence of the improper attitude there is usually, to a greater or less degree, disuse of the active leverage function of the foot; the active lift of the calf muscle is replaced by exaggerated flexion at the knee, the foot being used somewhat as if it were a movable pedestal. (Fig. 335.)

FIG. 353.

Typical "flat foot" of moderate degree, illustrating the component elements of abduction and depression of the arch.

This disuse of active attitudes may be unnecessary, just as the outward rotation of the feet with which it is associated is a habit, a habit that is often the result of improper teaching. On the other hand, the habitual assumption of the passive attitude may be induced by injury or disease of the foot, or by corns or bunions, or by improper shoes. Under such conditions the strain of the leverage function increases the discomfort, consequently it is discontinued. It must not be inferred that such improper attitudes lead directly to weakness and discomfort, for in most instances, an ungraceful carriage and gait are the only ill effects. The improper attitudes must, however, lessen the power and resistance of the foot and they must be reckoned, therefore, among the predisposing causes of disability and deformity.

The passive attitude, it will be remembered, is the attitude of rest, in which the ligaments bear the greater part of the strain and in which the arches of the foot are depressed or obliterated.

The Weak Foot.

Synonyms.—Splay Foot, Flat Foot.

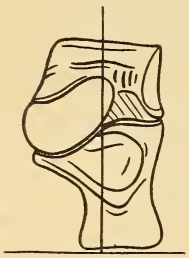
This introduction leads naturally to the consideration of the most important of the acquired disabilities of the foot, a disability whose most important characteristic in the mildest and in the most advanced type is the *persistence of the passive attitude*, or an approximation to it, in place of active motion and alternation of posture. Disuse of function is followed by restriction of motion, particularly in the

range of adduction and plantar flexion, and finally by persistent deformity, a deformity which is simply an exaggeration of the normal posture assumed when the foot supports weight. (Fig. 351.) This is the so-called flat foot. (Fig. 353.) At first glance, it may seem that the depression of the arch is the most noticeable peculiarity in a well-marked case of flat foot, and that the popular name is therefore an appropriate term, but on closer examination it will be evident that the normal relation between the leg and the foot is changed. This change, which from the functional standpoint is of far greater importance than the depth of the arch may be analyzed as follows:

The Anatomy of the Weak Foot.—1. The leg is displaced inward so that the weight falls upon the inner side of the foot; 2. The leg is rotated inward, so that a line drawn through its center, prolonged from the crest of the tibia, instead of falling over the second toe now points inside the great toe, or even over the center of the internal border of the foot. (Figs. 353–356.)

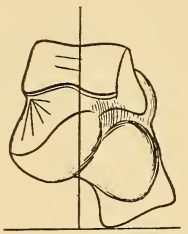
It has been stated that under normal conditions in the act of passive weight-bearing, the astragalus rotates downward and inward upon the os calcis, depressing its anterior and internal border until the movement is checked by the strong ligaments connecting the bones, the calcaneo-scaphoid, the deltoid and the interosseus; in other words the leg has a tendency to slip downward and inward from off the foot. In the weak foot this inclination has become an accomplished fact, for the normal movement has become so exaggerated by the distention of the ligaments and by the weakness of the supporting muscles that an actual partial dislocation has taken place. The astragalus has rotated and slipped far to the inner side of its normal position and to an attitude of exaggerated rotation and moderate plantar flexion, so that its head can be plainly felt on the internal border of the foot. The os calcis has been forced into an attitude of pronation. Its anterior extremity is depressed and turned slightly inward and its internal border is lowered. (Fig. 355.)

Fig. 354.



The relation of the astragalus to the os calcis.

Fig. 355.



The relation of the astragalus and os calcis in flat foot.

The scaphoid bone has been depressed with the head of the astragalus, although to a less degree, and has been forced further away from the os calcis, and with it the entire inner border of the foot is depressed also. Thus the depression of the arch is always accompanied by a bulging inward of the inner side of the foot.

The typical flat foot is, as it were, broken in the center (Fig. 366), the posterior division having turned inward and downward; that is, the astragalus has rotated inward and downward to an extreme degree and has slipped from off the os calcis. The latter bone, although

forced outward in its relation to the astragalus, still turns inward slightly, while the forefoot in its relation to the leg is greatly abducted. The dislocation may be so extreme that the entire sole of the foot rests upon the ground, and a callus even may be found at the point that usually represents the highest point of the arch, which now supports the greatest burden.

In this change of relation between the bones the arched part of the foot, or waist, appears much broader than normal, even broader than the front of the foot; the heel projects, the external malleolus is depressed and carried forward by the rotation of the leg and is much less prominent than normal; the internal malleolus is more prominent and with the astragalus it overhangs the bearing surface of the sole. The entire machine is twisted and out of gear, its motion is therefore very much restricted. It is manifestly impossible for the patient to adduct the forefoot, that is to turn it inward about the head of the displaced astragalus. Plantar flexion is also much limited, because of the permanent position of adduction and plantar flexion that the astragalus has assumed. Dorsal flexion, on the other hand, although it is actually restricted, may appear to be abnormally free, because the forefoot is abducted and slightly dorsi-flexed upon the head of the astragalus. (Fig. 353.)

Fig. 356.

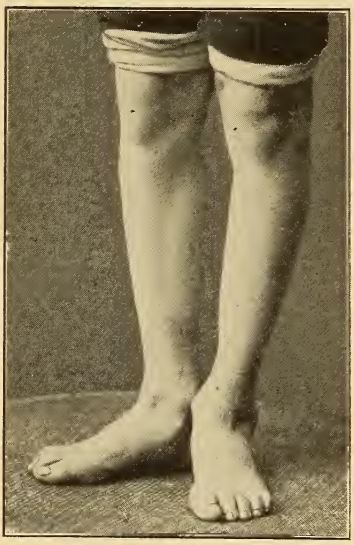
Weak feet, showing the inward rotation of the legs when the abducted feet are placed side by side.

The disability and its accompanying deformity, is found in every grade of severity. Pain begins when, the support of the muscles being insufficient, the ligaments begin to give way under strain, allowing the bones to occupy an abnormal relation to one another. It is evident, therefore, that the individual in whose foot the arch is well formed and whose ligaments are firm, will suffer from the symptoms of strain long before the arch has been depressed or deformity has become apparent; also that the lateral inward bulging, characteristic of advancing deformity, must be very great before the arch is completely flattened. In this type the prominent deformity is lateral displacement (valgus). On the other hand, if the individual has inherited a low arch, as is characteristic of certain races, or if, as the result of weakness in early life, the arch has been depressed or has never formed, accommodative changes in the bones will have taken place during growth, so that the flat foot

of this type will not be attended with as much change in its relation to the leg, and therefore, disturbance of function, as in the typical case that has been described. This latter class of cases exemplifies the popular type of flat foot that may exist without pain or disability and in which the most noticeable peculiarity is the obliteration of the arch (planus). (Contrast Figs. 357 and 358.)

In certain instances, abnormal laxity of ligaments allows deformity of the valgus type when weight is borne, yet the foot, controlled by efficient muscles, may be apparently normal in functional ability, while in other cases in which the ligaments are resistant and yet are subjected by insufficient muscular protection to over-strain, disability and pain may precede noticeable deformity.

FIG. 357.



Weak feet, arch not depressed.

It is very evident that the lowering of the arch is of secondary importance in the deformity and that the popular significance of painful flat foot, as an inherited and irremediable weakness, is most misleading. Yet it seems to have governed the treatment of the disability until very recently. On the one hand, the early cases were overlooked because the foot was not flat, while those in which the deformity was more advanced were simply neglected or were treated by simple supports beneath the arch or by operation, without regard to the loss of function, and therefore without hope of ultimate cure.

As has been stated, there is one feature common to every grade of the so-called flat foot; the foot regarded as a machine is weak, as compared to the normal standard—weak because of the persistence of the attitude of rest and relaxation, as contrasted with that of activity and strength, and weak because the proper relation between the power and the fulcrum is changed. Even the inherited flat foot or the flat foot which has never caused symptoms, is weak in the sense that, in use, it lacks the spring and elasticity characteristic of the perfect machine. The term weak foot may be used, then, to indicate all types of the disability. In one weak foot the arch has disappeared (Fig. 358); in another weak foot the arch is of normal depth but the foot is abducted or pronated in its relation to the leg. (Fig. 357.) In one case the deformity appears only under weight; in another the foot is held rigidly in the deformed position by muscular spasm. In one instance there may be great deformity without pain; and in another, disabling weakness and pain without deformity. In one case the foot is unable to perform its functions because of its inherent weakness, in another

the disability may be due simply to the improper use of a normal structure.

Pathology.—Supposing the foot to have been normal before it began to break down, it is evident that such deformity could not have been acquired without marked changes in its internal structure, and that its progress must have been attended with symptoms of discomfort and pain. In a general way, these changes are such as have been indicated by the description ; the ligaments on the internal aspect of the foot and of the ankle joint are weak and distended ; the unused portions of the articular surfaces of the joints may be denuded of cartilage, while new facets may have formed to accommodate the changed relations of the bones. For example, the external malleolus may be in direct contact with the os calcis ; evidences of injury and of abnormal pressure may be found in the thickened periosteum, in formation of osteophytes, while the internal structure of the bones has been changed as well, to adapt itself to the new conditions. The muscles which are no longer used in the leverage function, the plantar flexors and adductors, have become atrophied, a change that is made evident by the shrunken calf. The muscles on the inner border of the foot have been over-stretched, while those on the upper and outer part have become shortened and contracted. Such a foot represents an extreme, it may be an irremediable degree of deformity. The machine is completely broken down, it can no longer perform its proper function, it is even less efficient than the wooden foot, because use is attended by discomfort.

Etiology.—In all cases the actual symptoms of pain and disability are due to a disproportion between the burden or strain and the ability of the machine to perform it.

This theory accounts for the fact that the weak foot, although very common in childhood, does not as a rule, cause troublesome symptoms until adolescence, when the weight and strain put upon it are increased. It explains why the foot, which may be fairly normal in structure breaks down often in later adolescence or early adult life when the continuous strain of regular occupation is undertaken. It is evident also that an occupation that requires the long continuance of the passive attitude, that of waiters, cooks and bar-tenders for example, exposes the feet to greater strain than one which permits alternation of postures and that the symptoms are likely to be more severe and the deformity to be greater among those who are obliged to labor than among those who are not. Over-work or strain, of occupation or otherwise, may be temporarily disproportinate because of general weakness, as for example, during pregnancy or after recovery from exhausting disease ; or because of local injury or disease of the foot itself which weakens it directly or induces improper attitudes. On this theory one may very easily explain what has proved such a stumbling block for students, viz., that there is no constant relation between the degree of deformity and the severity of the symptoms ; for although all flat feet are weak feet yet all weak feet are not necessarily painful feet. Pain is not caused because the foot is flat ; it is a symptom of progressive deformity, of

strain and injury to the joints; it shows that the foot is becoming flat or it is a symptom of injury that the weak or flat foot has received. The progress of the deformity may be temporarily or permanently checked at any stage, either by a removal of the exciting cause or because of the resistance of the tissues; then the pain ceases. On the other hand, this stability may not be attained until the entire sole of the foot rests upon the ground, and even then the patient may suffer from discomfort and pain.

This conception of the foot as a machine, of which grades of efficiency may be recognized, has a great advantage since it enables one to perceive wherein a foot is weak even though the weakness causes no symptoms whatever. Thus one is enabled to prevent deformity by teaching the patient to avoid the extra strain that improper attitudes entail, and to strengthen the muscles on whose ability its integrity depends. Finally from this standpoint one may better appreciate the weakness and deformity that is often the direct result of improper shoes, a subject that will receive more extended consideration elsewhere.

Statistics.—A brief analysis of a thousand cases of so-called flat foot treated at the Hospital for the Ruptured and Crippled will represent fairly the points of general interest in this class of cases.

THE AGE AND SEX OF THE PATIENTS.

Age.	Males.	Females.	Total.
Ten years or less	68	30	98
Ten to fifteen	112	87	199
Fifteen to twenty	144	83	227
Twenty to twenty-five	94	53	147
Twenty-five to thirty	68	41	109
More than thirty	132	88	220
	618	382	1,000

Foot affected: right, 133; left, 138; both, 729.

In fifty-eight cases the cause of the disability appeared to be injury, and in sixty-five instances it was, apparently, due to rheumatism or to rheumatoid arthritis. The symptoms usually appear first in one foot, and as a rule, they are at all times more marked on one side. Of five hundred and sixty-nine instances, in which the duration of symptoms was recorded, it was six months or less in four hundred and nine.

The age of the patients is of interest as bearing on the question of prognosis. Four hundred and twenty-six were between ten and twenty years of age, and seven hundred and eighty were less than thirty.

Hospital statistics cannot adequately represent the subject of the weak foot, for as a rule, it was because of disability and pain, not for the deformity or for the milder type of symptoms, that these patients applied for treatment. In the larger proportion muscular spasm and rigidity were present, in two hundred and thirty-four cases to such a degree that forcible over-correction was advised, an operation rarely necessary in private practice.

It is in childhood that the prevention of subsequent weakness and deformity is of the first importance, yet but ninety-eight children of ten years of age or less are recorded, and of these a large proportion were brought, not for weakness or deformity, but for treatment of the symptomatic in-toeing.

Symptoms.—As has been stated, the symptoms of the weak foot, although similar in type, vary in severity according to the local condition and the disturbance of function, the work to be performed, and the susceptibility of the individual. The earliest symptom is usually a sensation of weakness; the patient begins to recognize as familiar, a feeling of discomfort, of tire and strain about the inner side of the foot and ankle; sometimes after long standing, a dull ache in the calf of the leg, or pain at the knee, hip or in the lumbar region, symptoms more common in women than in men; or after over-exertion a momentary sharp pain radiating from the point of weakness, thus the patient often dates the history of his trouble from a long walk. After a time the patient may become aware that he is accommodating his habits to his feet; he rides when he once walked, he sits when he once stood, he no longer runs up or down stairs or jumps off the street car. His feet have lost their spring as he expresses it, which means that the foot is no longer supported and controlled by muscular activity and is no longer used as a lever. Not infrequently, early symptoms are pain and tenderness at the center of the heel, explained in part by the jarring heel walk which is always assumed when the foot is weak, and in part by the strain upon the attachments of the deep plantar ligaments. The patient may complain that he cannot buy comfortable shoes; the reason is that the weak foot under use is changed in shape, so that the shoe that was comfortable in the morning compresses the foot painfully at night; thus increasing discomfort from corns, bunions, painful great toe joints, and deformities of the toes is experienced. Coldness and numbness, congestion and increased perspiration, caused by the impaired circulation and weakness, are common symptoms in this class of cases. Actual pain is, as a rule, felt only when the foot is in use; it ceases under temporary rest or relief from disproportionate work, and it is this remittance of symptoms, together with the fact that the discomfort is usually more marked in damp weather, that leads so often to the mistaken diagnosis of rheumatism. The foot is weak and vulnerable; the patient recognizes the fact that he has what he speaks of as a weak ankle, or sprain, or gout, or rheumatism, but if he has accommodated himself to the weakness, but little discomfort is experienced. In many instances such relief or accommodation is impossible, and it is therefore among the working class that one oftener sees the frank and rapid development of the disability and deformity. The range of motion becomes more and more restricted; the habitual attitude, at first exaggerated to deformity only under the influence of the weight of the body, remains as a permanent displacement of the bones. The weak and dislocated foot is subjected to constant injury, to what may be likened to a succession of slight sprains, so that local congestion,

tenderness and swelling may appear together with muscular spasm, rigidity, and pain on passive motion. Because of this rigidity of the foot, which has lost the power to accommodate itself to inequalities of the surface, the patient dreads to cross a rough pavement, for every misstep is a source of pain. Another symptom, the discomfort felt in changing from a position of rest to activity, which is usually present in slight degree at every stage, now becomes more prominent. The patient, after sitting or on rising in the morning, is unable to walk, but staggers and limps for several minutes, a symptom explained by the fact, that when the foot is at rest, there is a partial reposition of the displaced bones, which must be again forced into the deformed posture that has become habitual. The local tenderness and muscular spasm are increased by use, so that the patient may have difficulty in removing the shoe at night and the symptoms relieved by the rest of Sunday become progressively worse during the week. The pain and discomfort are more general in character, and are often referred to the dorsum of the foot, representing muscular rigidity and tension, and to the ankle where the external malleolus is grinding out a facet in the projecting os calcis. The patient may now complain of discomfort in the feet and cramps in the legs, even when in bed, and the appearance of weakness, awkwardness, and depression of spirits may be so noticeable that the case is sometimes mistaken for serious disease of the nervous system.

The appearance of such a foot has already been described, and the effect of the deformity on its function should be evident. The gait is slouchy and cloddy, what has been spoken of as the pedestal walk: the feet are simply pushed by one another, in the attitude of eversion, the knees are slightly flexed and the weight is borne entirely upon the posterior segment of the foot. The muscles have atrophied, the foot is cold and congested from its continued inactivity and it usually is bathed in perspiration. A certain range of motion remains at the ankle joint but adduction is absolutely restricted by the shortened and spasmodically contracted muscles on the outer and upper surface. This type represents, of course, only the severe variety that is more likely to be seen in hospital than in private practice; and it would seem, were it not for the evidence to the contrary which the histories of the patients present, that the nature of the trouble must be recognized at a glance. But in the milder and earlier cases the diagnosis is not always so easily made.

Diagnosis.—In all cases of suspected weakness of the foot, a thorough and orderly examination should be made, not only of its appearance, but also of its functional ability and of the manner in which it is used. Such an examination is not merely for the purpose of diagnosis, which is usually apparent, but in order that the amount and character of the temporary or permanent changes in structure and function may be properly estimated.

Attitudes.—One begins the examination by noting the manner of standing and walking. The heel walk, the exaggerated turning out of

the feet, the slouchy gait in which the leg is never completely extended, in which the power of the calf muscle is not applied, and in which the essential postures of the foot are disused, are all elements of weakness that should be corrected whether they cause symptoms or not.

Distribution of Weight and Strain.—The distribution of the weight of the body and the habitual use of the foot are often made evident by examining the worn shoe. If it is bulged inward at the arch or worn away on the inner side of the sole, it shows weakness. (Fig. 360.) The same observations are then made on the bare feet, particular attention being paid to the line of strain or leverage; thus a line drawn down the crest of the tibia from the center of the patella, continued over the foot, should meet the interval between the second and third toes; if it falls over or inside the great toe, it shows that the foot is working at a disadvantage. (Fig. 352.)

Contour.—The contour of the foot should then be examined; its internal border should curve slightly outward, so that if the feet are placed side by side with the toes and heels in apposition, a slight interval remains between them; if this slight concavity is replaced by a noticeable convexity, when weight is borne the foot is weak. (Fig. 357.) This change in contour is the earliest and sometimes the only evidence of deformity. The arch of the foot, properly protected by the muscles and by a proper attitude, sinks but slightly under weight; there is a slight elasticity only, as the strain is thrown more to the inner side of the median line, and if the depression is marked it shows weakness.

Bearing Surface.—The exact amount of bearing surface may be shown by an imprint upon carbon paper or by smearing the sole with vaseline, then as the patient stands upon a sheet of white paper the outline of the foot should be traced, so that the relative size of the imprint to that of the foot may be shown and compared with the normal standard.

Another method is that suggested by Lovett. The patient stands upon a square of plate glass fixed in a table, so that by means of a mirror beneath, the bearing surface may be examined under different degrees of pressure and in different attitudes. (Fig. 361.)

The Range of Motion.—The balance of the foot, as shown by the range of motion, is next to be tested, for its limitation is one of the earliest signs of improper attitudes and of weakness. This range of motion varies somewhat within normal limits; it is usually greater in childhood than in adult life, greater in the slender than in the massive foot, and greater in the foot used properly than in one that is not. The first test is applied to simple dorsal and plantar flexion; the leg must be fully extended at the knee, the line of strain must be in its normal relation, so that the foot may be neither adducted nor abducted and the observation must be made on its outer border.

In this position the patient should be able to flex the foot from ten to twenty degrees less than the right angle, and to extend it from forty to fifty degrees beyond the right angle, the range of motion being from fifty to sixty degrees. (Figs. 336, 337.)

By far the most important test is that of the power of adduction or inversion of the foot, the test of the medio-tarsal and sub-astragaloid joints, a motion in which the os calcis is drawn forward and inward under the astragalus, while the forefoot is flexed about its head. With the leg extended and the patella pointing forward the foot is turned inward as far as possible; the elevation of its inner border or supination and the turning in of the heel are well illustrated in Figure 338; the actual range of adduction is somewhat difficult to measure, but it is about thirty degrees. Even the mild and early cases of weak foot usually show some limitation of this most important motion and in many instances it is completely lost, the patient turning the entire leg in the effort to adduct the foot. The less important motion of abduction may be tested also (Fig. 339); its range is about half that of adduction, so also the range of supination or inversion of the sole is nearly twice as great as that of pronation or eversion of the sole. In other words the internal border of the foot can be raised twice as far from the floor, as can the external border. The range of passive motion is then tested by pushing the foot in all directions. The range of dorsal flexion is from five to ten degrees beyond that of voluntary motion, while passive extension, so far as it applies to the ankle joint, is about the same as the voluntary, although the forefoot may be still farther bent downward at the medio-tarsal joint. The limit of passive adduction is considerably beyond that of voluntary inversion.[1]

Passive motion serves several purposes; contrasted with the range of voluntary motion it shows the habitual use of the foot, since the motion least used is most limited. It also makes evident the slight restriction of motion and the presence of local tenderness, which, even in early cases, are usually present. Thus, if pressure is made just in front of and below the internal malleolus, at the astragalo-scaphoid junction, and at the same time the foot is quickly adducted, the patient will complain of pain at the point of pressure and of a feeling of constriction and tension about the dorsum of the foot, before the normal limit of motion is reached. When the foot is dorsi-flexed the plantar fascia is put upon the stretch, and its condition may be noted, for a contracted and sensitive plantar fascia may cause symptoms of discomfort, that may induce improper attitudes and thus predispose to further disability.

Varieties of the Weak Foot.—This mode of examination will demonstrate the disability and permanent change in the machine, which must be overcome before a cure can be accomplished. By it one will learn to recognize several grades of weak foot.

1. The normal foot improperly used, as shown by the manner of standing and walking.

[1] As adduction and supination and abduction and pronation are always combined, one term is used to signify the movement inward or outward; thus, supination means adduction, abduction implies pronation. A fixed attitude of adduction and supination is called varus, a fixed attitude of abduction and pronation is called valgus. Varus and valgus signify, therefore, deformity. Thus the term valgus although it may be properly applied to designate the deformity of weak foot is usually reserved for the more extreme distortion of talipes. (See Figs. 338 and 339.)

2. The foot, which because of laxity of ligaments or insufficient muscular support, is forced by the weight of the body into an attitude of deformity; that is, in which the foot under weight falls into an abnormal attitude of abduction in its relation to the leg, as evidenced by the inward projection of its inner border and by the overhanging internal malleolus, showing that the leg has been displaced inward on the foot. As a rule, there is sufficient laxity of ligaments to allow a depression of the arch, as shown by the imprint, but in other instances, although the arch seems lower because of the characteristic attitude, in which the leg, as it were overhangs the foot, yet the imprint shows that there is no increase in the area of bearing surface. Indeed this may be even smaller than normal; thus an individual may suffer from so-called flat foot whose arch is actually exaggerated.

3. The weak foot, which shows typical deformity under use and in which the range of voluntary motion is somewhat limited, particularly in the direction of plantar flexion and adduction. Forced motion causes discomfort and pain, indicating a certain permanent accommodative change in structure, which is not apparent when the foot is not in use.

4. The foot which presents typical and permanent deformity, whether it is in use or not, and in which the range of both voluntary and passive motion is much restricted. In all of these varieties, however, the improper functional use of the foot, in the loss of active leverage, is very evident when the patient walks.

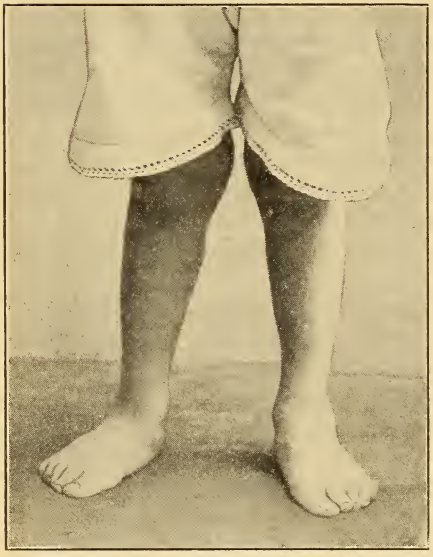
Limitation of Motion and Muscular Spasm.—Limitation of motion is caused by the accommodative changes in structure to the habitual postures or to the deformity. These are first evident in the muscles and ligaments and finally in the articular surfaces of the bones. Added to this underlying limitation of motion, there is usually a certain amount of muscular spasm, which varies in degree with the local congestion, irritation and inflammation of the joints and tissues. In the quiescent flat foot it may be absent but on renewed injury or over-work of the weak structure, it again appears. It depends also upon the irritable condition of the over-worked and contracted abductor muscles, practically the only group which retains functional power; thus the spasm, as has been stated in describing the severe and painful type of weak foot, is greater after the day's use and relaxes somewhat during the night. The degree of muscular spasm and rigidity corresponds with the intensity of the symptoms, but by no means with the depression of the arch or with the duration of the deformity.

Extreme Types of Weak Foot. 1. Persistent Abduction.—In one type of rigid foot the foot is twisted outward and upward. It may be pronated to such an extent that practically the weight is borne upon the heel and the ball of the great toe. In such instances the astragalus, although rotated inward upon the pronated os calcis, is, of course, not plantar flexed nor is the anterior extremity of the os calcis depressed. The entire foot is simply held in an attitude of extreme abduction and dorsal flexion, by the spasm and contraction of the flexors and abductors, so that the leg must be bent at the knee and inclined

forward to bring the sole to the ground. Such extreme cases are uncommon. They are often the direct result of injury, so-called chronic sprain, and when the deformity is reduced the arch will be found to be exaggerated in depth. Less extreme types of this class are often seen and they serve to emphasize the statement that the most important disability of the weak foot is due to the change from the normal relation between the leg and the foot and not to the depression of the arch, which is in most instances a secondary deformity.

2. Pes Planus.—As has been stated already, and as is well known, there is a type of painless flat foot sometimes called pes planus in which the flatness of the foot is more noticeable than the other components of the deformity that have been described. This is probably the result of inherited laxity of ligaments or of rhachitis or other form of acquired weakness in early life, so that a normal arch was never present. Such a foot controlled by normal muscles, may be strong and efficient but it is nevertheless deformed, and it is doubtful if its possessor ever could attain the grace and elasticity of gait possible under normal conditions. It is said also, that a low arch is normal in certain races, for example the negro, but it is certain that the American negro is not exempt from the pain and disability incidental to the broken-down foot, whether his arch was originally low or not.

Fig. 358.



Weak feet and slight knock knees.

It is evident, of course, that the breaking down of a properly shaped foot, provided with normal ligaments, will be attended by greater pain and greater disability than of one in which the arch was originally low and of which the ligaments were weak, because it is during the progression of the deformity and particularly in its early stages, that such symptoms are most prominent. When the bones of the arch rest upon the ground or when final stability has become assured, pain may cease, and permanent accommodation to the new conditions may increase the ability of the deformed member. Such an outcome might be quickly accomplished in the foot originally flat, while in the other instance, the symptoms although remitting from time to time, might continue during the life of the sufferer.

Weak Foot in Childhood.

There can be no doubt that in many instances, the origin of the weak foot may be traced to early childhood. Certainly, deformities and improper attitudes are very common at this period, and it is much more likely that they are ingrown than outgrown. Actual pain from the weak foot is rare at this age. The child may complain of fatigue and may be weak and awkward, but it is usually because of the very evident deformity, rather than because of symptoms, that advice is asked. In these cases, as in every case, the habitual attitudes and use of the feet are of the first importance.

Out and In Toeing as Symptoms of the Weak Foot in Childhood.—One of the most frequent of the improper postures is that of exaggerated outward rotation of the feet, which is not only an ungraceful attitude, but a direct cause of weakness as well. The opposite attitude of inward rotation, the so-called "pigeon-toed" walk, is most offensive to relatives and friends, and it is for correction of the attitude that the child may be brought for treatment. The attitude is, in many instances, a sign of the weak foot, for on examination the bulging on the inner side, the inward rotation of the leg in its relation to the foot, and the flattened arch, show very plainly that it is the foot and not the attitude that requires treatment; in fact, the attitude is, in this class of cases, really a safeguard against increasing deformity and it will correct itself when its cause is removed. Particular emphasis is laid upon this point, which is very generally over-looked, because the routine treatment of the "pigeon toes" in these cases might be the cause of direct harm.

Fig. 359.

Congenital flat foot. Rigid deformity of an extreme type illustrating the component abduction and obliteration of the arch.

Weak Ankles.—"Weak ankle" is a term popularly applied to the weak foot of childhood, in which the foot is in a position of valgus when in use, so that the shoe is worn away on its inner side. Weak ankles are very common in very young children and are often one of the results of general weakness due to defective assimilation. At this age the foot is, in addition, usually flat (Fig. 358), but in the valgus or weak ankle of later years the arch is often practically normal in outline.

Outgrown Joints.—In older children prominent or "outgrown" joints often attract the mother's attention; the internal malleoli appear

prominent because of the position of valgus, or because of the eversion of the feet the malleoli may strike against one another, "interfere," and thus there may be an actual hypertrophy of the projecting bones from local irritation.

Another type is the long slender foot in which the scaphoid bone is prominent because of the strain and pressure put upon it by the improper attitudes; its position is often shown by the point of wear in the leather of the shoe. (Fig. 357.)

In the weak foot of childhood, although restriction of voluntary and passive motion may be present, there are, as a rule, but little local tenderness and muscular spasm, and as has been said, but little actual pain; thus it differs greatly from the adult type, for the reason that the weak foot in childhood has not been subjected to the strain of constant occupation or to the burden of the increased weight of the body. There is another important difference also; the foot of the adult is obliged to bear greater strain than any other part, and although normal in structure it may be over-strained, so that in many or in most instances the weakness of the foot may be the only disability. But in childhood, when such exciting causes are absent, a weak foot is very often a local indication of general weakness and loss of tone.

Fig. 360.

Flat foot, extreme deformity in childhood.

General Weakness. — The direct effects of the weak and painful foot have been described in detail. It must be borne in mind that the feet are the foundation of the body, and that an insecure foundation affects the entire mechanism. General functional weakness and awkwardness, the flat chest, round shoulders or other curvatures of the spine, are often observed as accompaniments or effects of weak feet. Thus, as a rule, the systematic treatment of any form of postural weakness must include the treatment of the feet as well.

Recapitulation.—The disability and deformity of the weak or so-called flat foot are caused by a disproportion between the strength of the foot and the weight and strain to which it is subjected.

The foot may be weakened by injury or disease; it may be overburdened by the body-weight, or over-strained by laborious occupation, or the broken-down foot may be simply one indication of general bodily weakness. It is unnecessary to enumerate all the various factors that singly or combined lead to this disability. It may be stated, however, that the weak foot is in many, or most, instances the only disability that demands treatment. Its most constant predisposing causes are

improper shoes, and the mechanical disadvantages to which it is subjected by the assumption of improper attitudes.

All weak or flat feet are mechanically weak, but all weak feet are by no means painful feet. Pain, the symptom of over-strain or injury, bears no definite relation to the degree of deformity.

In certain instances, exaggeration of the arch may be combined with persistent abduction of the foot; in others, the flattening of the arch may be the most noticeable deformity, but in most cases, the two are combined in varying degree. And as each deformity is an evidence of weakness, it seems hardly necessary to make a radical distinction between the two, except as regards prognosis. For the abducted foot in which the arch is intact is almost always an acquired deformity of short duration, whereas in the case of the foot in which the arch is obliterated the deformity usually dates from early childhood and it is, therefore, much less amenable to treatment as far as perfect cure is concerned.

Treatment.—The principles of the treatment which leads to the permanent cure of the weak and deformed foot are very simple, but the application varies somewhat according to the grade and duration of the deformity. The object of treatment is to so change the weak foot that it may conform, not only in contour but in habitual attitudes and in power of voluntary motion to those of the normal foot, because complete cure is impossible unless normal function is regained. The first step must be, therefore, to make passive motion free and painless to the normal limit. In other words the obstructions to the motion of the machine must be removed before the power can be properly applied; for the increase of muscular strength and ability, on which ultimate cure depends, is not possible while motion is restrained by deformity or by pain or by adhesions or contractions.

The weak foot, because of inefficient ligaments and muscles unable to hold itself in proper position, must be supported, in many instances, until regenerative changes have taken place in its structure. Such support is necessary to retain the joints in proper position, and to hold the weight and the strain in proper relation to the foot, otherwise normal motion is impossible. When these essentials are provided, the patient may cure himself by the proper functional use of the foot, and by the avoidance of attitudes that place it at a disadvantage.

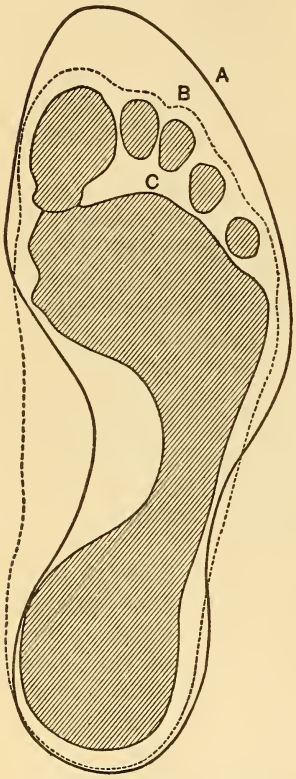
It may be well to describe, first, the treatment that must be applied to all classes of weak foot in which a cure is to be attempted, and which by itself is sufficient in the milder types, before calling attention to the modifications that may be necessary in special cases.

The Shoe.—In practically all cases it will be necessary to provide the patient with a proper shoe, for the shoe is usually the direct cause of the minor deformities, and indirectly, in many instances, of more serious disability. Indeed most of the deformities and disabilities of the foot are incidental to civilization and are therefore confined to the shoe-wearing people. The direct effect of the ordinary shoe is to lessen the size and balancing power of the fulcrum by cramping the toes

together while the high heel throws more strain upon the arch and the ankle. Indirectly it causes deformities, corns, bunions and the like, which serve to make active movement or leverage painful, so that it is replaced by the passive attitude.

The proper shoe should contain sufficient space for the independent movements of the toes. This motion is illustrated in the walk of the barefoot child. As the weight falls on the foot the toes expand, and as the body is raised on the foot they contract. The important leverage action of the great toe and the support afforded by it to the arch of the foot have already been mentioned. The shape of the sole should correspond to the shape of the foot and the heel should be broad and low. (Fig. 361.)

Fig. 361.



The proper relation of the sole to the shape of the foot. A, outline of sole; B, outline of foot; C, imprint of foot.

The prevention of distorted toes and the discomforts that result from the abuse of the foot is of great importance in childhood, but unfortunately, little children are often seen wearing shoes of the shape usually assumed at years of discretion. In this regard, girls suffer more than boys as women do more than men. The girl who may have worn comparatively harmless shoes until the age of ten years or thereabouts, changes suddenly to the high heel and narrow sole, and the process of distortion begins, the amount of distortion and the degree of discomfort depending on the amount of work required of the foot. Wide soles without heels should be worn as long as possible by children because of the greater stability and because the high heel limits the necessity for, and therefore the use of, the entire range of motion of the foot and ankle.

Raising the Inner Border of the Shoe.—A simple expedient in the treatment of the weak foot and an aid in balancing it properly, is to make the inner border of the sole and heel of the shoe slightly thicker in order to throw the weight toward the outer side of the foot. This is of especial importance in the treatment of the slighter degrees of what is known as weak ankle but it is always of service in the treatment of any grade of weak foot.

Attitudes.—When the patient stands, properly balanced in the proper shoe, his attention is called to the three elements of weakness. He is instructed to guard against valgus (Fig. 351) by throwing the weight on the outer side of the foot (Fig. 352) and to guard against

abduction by holding the feet parallel with one another in walking (Fig. 334); the significance of the bulging on the inner side of the foot is pointed out to him, how this may be prevented by the avoidance of the postures just indicated and by aiding the arch by the power of the great toe. The importance of leverage is shown him, that he must try to press down the sole of the shoe with his toes and employ the active lift of the calf muscles by fully extending the leg and raising the body on the foot from time to time. (Fig. 334.) Finally, he must avoid long continuance in one position, especially the passive posture, which simulates the attitude and deformity of flat foot. In short he must be instructed in the mechanics of the foot and taught how the weak foot may be protected as well as strengthened.

Exercises.—It is important, also, to show the patient the normal range of motion of the foot, motion which, if restricted, must be regained by voluntary and passive exercise. Voluntary exercise should be devoted to strengthening the adductors and plantar flexors; thus the foot should be adducted and supinated (Fig. 338) over and over again at every opportunity. Tip-toe exercises are especially useful; the patient, holding the feet parallel, raises the body on the toes twenty to one hundred times, resting in the intervals on the outer border of the feet. The best of all exercises is, however, the proper walk, in which the leverage power of the foot is employed and in which it passes through the proper alternation of postures. (Fig. 334.) Treatment by massage and special gymnastic exercises is of course of benefit, if the patient can command it, although by no means essential to the cure.

Support.—In many instances the simple treatment that has been outlined is all that is required and the symptoms of tire and strain are quickly relieved, but in the more advanced type of disability the patient is not able to prevent deformity voluntarily, consequently a support is necessary to hold the foot in proper position and to relieve discomfort. It is usually necessary in the treatment of the weak foot of childhood, because one cannot command the aid of the patient.

In selecting a support for the weak foot the nature of the deformity that is to be prevented must be borne in mind; that the acquired flat foot, for example, is not a direct breaking down of the arch, as is usually taught, but a lateral deviation and sinking—a compound deformity, as has been already described. (Fig. 351.) Thus a brace, to be efficient, must hold the foot laterally as well as support the arch. But it must not prevent the normal motions of the foot, and thus interfere with the increase of muscular strength and ability, on which ultimate cure depends.

The supports that have been ordinarily used for flat foot do not fulfil the conditions; the pads and springs placed beneath the arch are intended to support it by direct pressure without regard to the valgus or the abduction; they are usually ill-fitting and are often of such length and shape as to splint the foot and thus to restrict its motion. Leg braces which control the valgus do not often hold the foot accu-

rately, and their weight and unsightliness are fatal objections to their use in the early cases, in which prevention of subsequent deformity is of such importance.

A brace should never be applied to a deformed and rigid foot because it is unable to shape itself to the support; the spasm and rigidity must be first relieved by preliminary treatment, as will presently be described.

The Construction of the Brace.—To properly construct a brace to meet these conditions, it is necessary to provide the mechanic with a plaster cast of the foot, taken in the attitude in which one wishes to support it. Such a model may be easily and quickly made in the following manner.

THE PLASTER CAST.—Seat the patient in a chair; in front of him place another chair of equal height; on it lay a thick pad of cotton batting and cover it with a square of cotton cloth. Put about a quart of cold water into a basin and sprinkle plaster of Paris on the

FIG. 362.

The attitude in which the plaster cast should be taken. In the reproduction, the chair upon which the foot is resting, has been removed.

surface until it does not readily sink to the bottom; then stir. When the mixture is of the consistence of very thick cream pour it upon the cloth. The patient's knee is then flexed, and the outer side of the foot, previously smeared lightly with vaseline, is allowed to sink into the plaster and, the borders of the cloth being raised, the plaster is pressed against the foot until rather more than half is covered.

The foot should be at a right angle with the leg and the sole should be in the plane perpendicular to the seat of the chair. (Fig. 362.) As soon as the plaster is hard its upper surface is coated with vaseline and the remainder of the foot is covered with plaster; the two halves are then removed, smeared lightly with vaseline and bandaged together. The interior is dampened with soapsuds and it is then filled with the plaster cream. In a few moments the plaster shell may be removed, and one has a reproduction of the foot, which, when properly made, should stand upright without inclination to one side or the other.

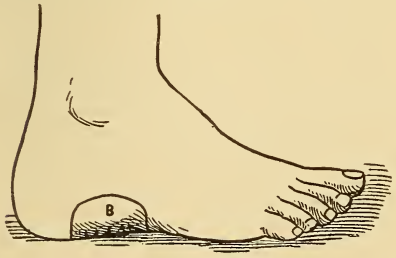
Fig. 363.

A, the astragalo-scaphoid joint. The internal flange of the brace should rise well above all the prominent bones to a point about half an inch below the malleolus.

In many instances it will be of advantage to deepen in the plaster model the inner and outer segments of the arch, in order that the arch of the brace may be slightly exaggerated, especially at the heel, so that the depression of the anterior extremity of the os calcis may be prevented.

The Brace.—Upon the model the outline of the brace is drawn as illustrated in the diagrams. The best sheet steel, 18 to 20 gauge, cut after the pattern is moulded upon it and tempered, so that, as it is applied for the purpose of preventing deformity, it may be practically unyielding to the weight of the body.

Fig. 364.



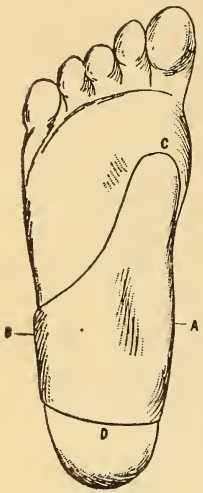
B, the calcaneo-cuboid junction. The external flange extends from the center of the heel to a point slightly behind the base of the fifth metatarsal bone.

It will be noticed that the brace clasps the weak part of the foot and holds it together; the broad internal upright portion (Fig. 363) covers and protects the astragalo-scaphoid junction, rising well above the scaphoid; the external arm covers the calcaneo-cuboid junction and the outer aspect of the foot to a height sufficient to hold the foot securely. (Fig. 364.) The sole part provides a firm, comfortable support, yet, reaching only from the center of the heel to just behind the ball of the great toe, it does not restrain the normal motions of the foot. (Fig. 365.)

The brace may be nickel plated and japanned, which makes a smooth finish, or tin plated, or galvanized, which makes a more durable covering. It may be covered with leather, or an inner sole may be placed

on its upper surface; but this is not usually necessary. As it is fitted to the foot, it finds and holds its own place in the shoe, so that no attachment is required; thus it may be changed from one shoe to another. Not only does it hold the foot laterally and from beneath, but there is an element of suggestiveness in the slight leverage action which is very important.

Fig. 365.



C, the great-toe joint
D, the center of the heel.

The Positive Action of a Proper Brace.—The patient, instructed to throw his weight upon the outer side of the foot and wearing the shoe which has been tilted in the same direction by thickening the inner border of the sole and heel, presses down the external arm and thus lifts the internal flange against the inner side of the foot, which is instinctively drawn away from the pressure and thus toward the normal contour; he no longer everts or turns the feet outward in walking, and he is not likely to assume the passive attitude, because of the suggestive lateral pressure of the support; thus it becomes a positive aid in the physiological cure.

The shape of the brace, in general like that of the diagram, is modified in certain cases; for instance, the entire internal aspect of the foot may be weak and must be covered by the internal flange. In very heavy subjects the sole portion must be made larger although this is a detriment, as it lessens the leverage action; other slight modifications may be necessary in special cases. If any portion of the rim of the plate causes discomfort, the edge may be turned away slightly at the point of pressure by a wrench. After a few days the patient no longer notices the presence of the brace, and as its presence in the shoe is not evident, it may be worn indefinitely.

It is usually necessary for from three months to a year or longer, according to the condition of the patient and the strain to which the feet are subjected. The brace, properly made and adjusted under the proper conditions, causes no more pressure or discomfort than a well made shoe, for its principle is quite different from that of the ordinary supports that are in common use, to which this objection has been made. This brace supports the arch primarily by preventing abduction, consequently its pressure is first felt upon the lateral aspect of the foot, a pressure that the patient can relieve by improving his attitude. The brace should afford support when necessary, and at all times suggest and enforce a proper attitude; it is, however, but one of the essential factors in the general scheme of treatment.

In the treatment of children, the foot should be moved in all directions but particularly in dorsal flexion and adduction to the full limit at morning and at night, until the child has regained the normal muscular power and ability. Special gymnastics and massage are always desirable and they may be necessary in certain cases. Bicycling

may be cited as one of the best, and roller skating as one of the worst exercises for the weak foot. A year is about the time required for a cure of the weak foot in childhood, although attention to the shoes and to the attitudes must be continued indefinitely.

The Rigid Weak Foot.

One may now contrast with these mild types of weakness that have been described, those cases of extreme deformity in which the symptoms are disabling and in which the foot is rigidly held in the deformed position by muscular spasm and by secondary changes in its structure. Such cases, often considered hopeless as regards a cure or even relief, are in reality the most satisfactory from the remedial standpoint, and in no other type of painful deformity can so much be accomplished by rational treatment as in this class. The deformity must be considered as a dislocation in which the astragalus has slipped downward and inward from off the os calcis, which in turn is tipped downward and inward and into a position of valgus. The remainder of the foot is turned outward, so that the relation of the leg and the forefoot is entirely changed; in fact the forefoot is almost entirely disused. (Fig. 366.)

Corresponding to the duration of the disability, one finds accommodative changes in the soft parts and in the bones, but such changes are by no means as marked as those recorded in the reports of autopsies which have been made in cases of advanced and irremediable deformity. In fact, by far the greater number of patients are young adults in whom the extreme deformity is of comparatively short duration, and in whom complete cure is possible.

In the treatment of such a condition, one must first reduce the dislocation and overcome the obstacles that contracted muscles and ligaments may offer to free and normal motion; then rest must be assured to the injured and congested parts in order to relieve the patient from the pain from which he has suffered so long.

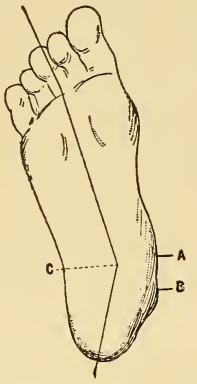
Forcible Over-correction.—By far the most effective treatment is forcible over-correction of the deformity, under anæsthesia. When the patient is under the influence of the anæsthetic the muscular spasm relaxes, and it will be seen that this accounts for about half of the restriction of motion, the remainder being caused by the adaptive changes that have been mentioned. One now endeavors to overcome this residual obstruction; and to assure the patient against a relapse, by fixing the foot in the position of extreme adduction and supination, the attitude directly opposed to that which has become habitual.

This is the object of forcible over-correction as the first step in the systematic repair of the disabled mechanism; its principle must not be confounded with forcible correction carried out with the object of simply remoulding the arch of the foot, or in which the simple correction of the deformity is the object in view.

One first extends the foot forcibly, then flexes it to the normal limit, then abducts and adducts, the different motions being carried out over

and over until the rigid foot has become perfectly flexible. In cases of long standing it is often necessary to draw the patient to the end of the table, so that the foot may be taken between the knees, in order to supply the required force by the thigh muscles. This forcible manipulation is accompanied by the audible breaking of adhesions, and the complete disappearance of the deformity. In certain instances it will be necessary to divide the tendo Achillis when, for example, the range of dorsal flexion is limited by resistant accommodative shortening of the calf muscles, or when there has been very great pain and tenderness at the medio-tarsal joint, and it is desired to remove the strain of leverage completely; traumatic cases come especially under this head. Tenotomy has one great advantage, it necessitates longer fixation in the plaster bandage, and gives the patient the benefit of rest, and the

FIG. 366.



The deformed foot before operation. A, the projecton of the displaced astragalus and scaphoid; B, the inner malleolus; C, the mediotarsal joint, showing the outward displacement before, the inward rotation behind, this point.

FIG. 367.

The over-corrected foot, showing the reversal of the lines of displacement. (See Fig. 368.)

opportunity for prolonged after-treatment. When the passive range of motion has been regained, the foot is turned downward, then inward and upward into the position of extreme varus. By this manipulation the os calcis is drawn under the astragalus and thrown into the supinated position, and the scaphoid is flexed about and under the head of the astragalus, which is then lifted to the limit of normal flexion. The attempt is always made to bring the extreme outer border of the inverted foot up to a right angle with the leg, which is the limit of normal flexion in this attitude. The foot, thickly padded with cotton, is then fixed in this posture of club foot by a firm plaster of Paris bandage extending to the knee. (Fig. 368.) Surprisingly little discomfort, considering the force that it is sometimes necessary to apply, is experienced after the operation. The familiar and often intense pain, from which the patient has suffered so long, is entirely relieved by the

correction of the deformity ; there is often a sense of tension about the outer side of the ankle and dorsum of the foot, but this is not, as a rule, of long duration.

Functional Use in the Over-corrected Attitude.—As soon as possible, often on the following day, the patient is encouraged to stand and walk, bearing his weight on the foot. Walking serves two purposes : to still further over-correct the deformity, and to accustom the patient to a posture entirely different from that so long assumed. Meanwhile the contracted tissues on the outer side become thoroughly over-stretched ; the weakened ligaments and muscles on the inner side are relaxed, and the local irritation rapidly subsides under the rest from the constant injury to which the foot has been subjected.

The patient is not confined to the bed or house, although if both feet are in plaster bandages, crutches are of course necessary. The time that the feet should remain in the over-corrected position, depends upon the duration of the deformity and the severity of symptoms, or from one to six weeks, the usual time being about three weeks. At the end of two weeks, or whenever the patient can support the weight on the plaster bandage, without a sensation of discomfort, it is removed ; the foot is placed in the normal attitude, and a cast is taken for the brace. Immediately after this is made, the foot is returned to the club-foot position and the plaster bandage is re-applied. When the brace is ready, the plaster bandage is finally removed ; the foot is now in good position, and in many instances the arch is exaggerated in depth. For the first few days, prolonged soaking in hot water, or the use of the hot-air bath, with subsequent massage, at intervals during the day, will be found useful in overcoming the swelling and local tenderness that may remain. It is always insisted that a new shoe of the Waukenphast pattern shall be obtained, the sole and heel of which are raised a quarter of an inch on the inner border, to aid in the balancing of the weak foot. The brace is then applied, and the patient is never allowed to walk without its support. When the shoe is removed at night, he is instructed to turn the toes in and to bear the weight on the outer side of the foot until it has regained its strength ; in other words, the deformity is never allowed to recur.

FIG. 368.

The forcible over-correction of flat foot. The proper position in the plaster bandage.

Systematic Manipulation.—The systematic treatment is then begun by the surgeon and the patient, the first essential being the attainment of free and painless passive motion in all directions. These motions, which have been so long restrained by deformity, cannot be regained without effort, and during this critical stage, treatment must be carried out by the surgeon himself; if he trusts to the patient or to his friends, a cure is out of the question. At least once a day the full range of motion must be carried out to the normal limit. Three motions, abduction, flexion, and extension are usually free and painless; but the fourth, that of adduction, is almost invariably resisted by the same quality of muscular rigidity that was present before the operation. By far the most effective method of overcoming this resistance is conducted as follows: the patient being seated in a chair, the surgeon sits or stands before him. Let us suppose that the left foot is to be adducted or, as the patients express it, twisted. The surgeon places the foot between his knees; his left hand encircles the heel, the fingers grasping the projecting os calcis and tendo Achillis; the base of the palm lies against the medio-tarsal joint on the inner aspect of the foot; the right hand grasps the outer side of the forefoot and toes; then, by steady pressure of the thigh muscles, the forefoot is forced downward and inward (adducted and supinated) (Fig. 338) over the fulcrum formed by the projecting palm, which lies upon the left knee, the fingers holding the heel steadily in place. This inward twisting is at first resisted by a mixed voluntary and involuntary muscular spasm, which gradually gives way under steady pressure. When the limit of adduction has been reached, the foot is firmly held until all pain has subsided; then the patient is instructed to attempt voluntary movements while the foot is guided by the hands; in other words, the patient attempts to adduct the foot while the surgeon supplies the power, which in all cases of this type has been completely lost. This passive manipulation to the extreme limit of normal adduction, plantar and dorsal flexion, is continued from day to day until there is no longer a sensation of pain or tension; for as long as there is the slightest spasm or painful restriction, so long is the voluntary motion limited, cure delayed, and relapse of deformity probable. During active treatment the patient, by the use of massage, active and passive motion, is constantly working to one end, namely, to regain the lost power of voluntary adduction.

The time necessary to rest the feet, to overcome the local irritation and muscular spasm, to regain, in part at least, the range of passive motion, and to place the patient in the same position, as regards a cure, as that of the milder type of deformity, is from three to six weeks. Usually the patients are told that a month will be necessary, and that at the end of that time they may return to work, free from pain and from the danger of relapse, and that the feet will constantly grow stronger, under the work which was before too great for their strength. The time necessary to reëducate the adductor muscles in their proper function depends, in great degree, upon the intelligence and persistence of the patient. Although in after-treatment massage and special exer-

cises are of benefit, the essentials are very simple ; they are an effective brace, a proper shoe, and the passive manipulation that has been described, until its object has been attained, and the proper walk, the best and easiest of exercises. Finally, one must force into the patient's understanding the method of protecting the weak foot by the alternation of strain, and by proper postures.

Other Varieties of Rigid Weak Foot.—The foot, which is fixed in the abducted position without depression of the longitudinal arch, is simply one variety of the rigid weak foot, which should be treated in the same manner. It may be stated also, that a very large proportion of the so-called chronic sprains of the ankle are of this type, and that the disability will yield very readily to treatment, conducted for the purpose of restoring impaired function, in the manner that has been indicated.

There are other cases, in which the deformity of flat foot is complicated by rheumatoid arthritis or chronic rheumatism, of which the evidence is seen in various joints but in which the pain and discomfort seem to be concentrated, in the feet, which are absolutely stiff and deformed. In such cases one can hardly expect a complete cure ; but although the function of leverage may not be regained, still one may hope, by overcoming the deformity, to hold the weight of the body in its proper relation to the foot, so that the pain of a progressive dislocation may not be added to the pain of disease. In a number of instances forcible correction has been employed by the writer in cases of this type, and in all, the improvement in the general condition, consequently in the resistance to the disease, after the relief of the local pain and discomfort, has been very great.

Between the two classes of cases, the mild and the severe, one finds every grade of deformity. All cases in which there is marked muscular spasm, local tenderness and swelling, require temporary rest ; in many instances, simply rest from functional use combined with massage ; in others, rest in a plaster bandage in the adducted position. In the milder and ordinary class of cases, the use of a brace and shoe will alone relieve spasm and pain, and the range of motion can usually be regained by manipulation, passive motion, and by the proper use of the foot.

Occasionally, even in childhood, one may encounter marked limitation of normal motion, particularly in dorsal flexion, not due to pain and muscular spasm but to actual shortening of the muscle. This may be the accommodative shortening that is characteristic of long-standing deformity ; in other instances it would appear to be the result of a slight and unnoticed neuritis or anterior poliomyelitis, which has resulted in muscular inequality. If the contraction does not yield readily to manipulation or to mechanical stretching, forcible correction and if necessary, tenotomy should be employed in the manner already described ; for whatever may be the theory of its causation, it is again emphasized that obstruction to motion in any direction must be overcome before a complete cure is possible.

Adjuncts in Treatment.—It must be apparent, that in many instances, the cure of the weak foot is out of the question, either because of the want of energy or opportunity on the part of the patient, or because of the local or general conditions, types familiar in out-patient practice.

The Thomas Treatment.—In such cases, raising and strengthening the inner side of the shoe by the wedge-shaped leather sole, as used by Thomas, splints the painful foot and aids in relieving the strain.

Plaster Strapping.—If the symptoms are more acute, the adhesive plaster strapping, as advocated by Cottrell and Gibney for the treatment of sprains, is often of service, although it is applied in a different manner, and with a somewhat different object in view. One end of a strip of adhesive plaster, about fifteen inches long and three inches wide, is applied to the outer side of the ankle just below the external malleolus; the foot is then adducted as far as possible, and the band is drawn tightly beneath the sole and up the inner side of the arch and leg, and is stayed in this position by one or two plaster strips about the calf. Narrow plaster straps are then applied about the arch and ankle, in the figure-of-eight manner, and a bandage is applied. The object of the dressing is to aid in holding the foot in the proper position, by the support and suggestiveness of the plaster, and to provide the firm compression about the arch that is always agreeable to the sufferer from weak foot. This treatment, combined with the built-up shoe, is often very effective in overcoming the acute and disabling symptoms of the weak and injured foot, which are, as has been stated, often the result of extra strain or injury, in other words a sprain of a weak foot. Consequently when these symptoms are relieved, the patient, who has become habituated to the weakness and deformity, considers himself cured.

Operative Treatment.—The various cutting operations for the relief of flat foot do not call for extended comment. The typical operation, the removal of a wedge from the astragalo-scaphoid region, aims at removal of deformity simply; functional cure is made impossible by the destruction of the medio-tarsal joint. It would hardly seem possible that adhesion between the astragalus and scaphoid bones could, for any length of time, withhold a recurrence of deformity of the nature and origin of flat foot, and in all cases that the writer has examined, in which this operation had been performed, there was still local tenderness and muscular spasm and even relapse of the deformity.

The operation of advancement of the posterior extremity of the os calcis, as proposed by Gleich, in order that it may be placed in relation to the leg somewhat like that of a Pirogoff amputation, offers little hope of ultimate cure, because the disability is not due to primary depression of the arch, therefore it cannot be cured by exaggerating its depth in this manner. The most innocent and rational of the operations for flat foot is the supra-malleolar osteotomy of Trendelenburg, in which the bones of the leg are divided above the ankle, and the distal extremity turned inward, with the aim of directing the weight

upon the outer border of the foot. In practice, the operation is by no means always successful, while the bow-leg deformity that results, if the object is attained, is an unfortunate accompaniment of the treatment. It may be mentioned in this connection that fracture at the ankle joint, followed by faulty union in a position of valgus, is a form of traumatic flat foot that may be cured by this operation. In operative treatment, the element of rest, necessary for weeks or months, must be taken into consideration, as explaining in part, the immediate favorable effect of whatever procedure is adopted. An investigation of final results will prove, I believe, as might be predicted from the nature of the deformity and the complex structure of the foot, that there is no short and easy method by which a cure may be attained.

In conclusion, the following points are again emphasized: Flat foot in its surgical sense, is a compound deformity, in which the abnormal relation between the foot and the leg, causing the improper distribution of the weight and strain, and disuse of normal function, is of vastly greater importance than the depression of the arch, which has given the name to the disability.

The weak and deformed foot can be cured, but only by the application of the simple principles that any mechanic would apply to a disabled machine whose structure and use were known to him; in other words, there can be no permanent cure of weakness and deformity unless normal function is regained, or effective treatment unless it has this end in view.

The term weak foot has this advantage over others that imply deformity, in that it may include the earliest indications of disability. Once weakness is recognized, its causes may be analyzed and appreciated at their proper value. Flat foot is a particularly objectionable and misleading term, and it should be discarded, or at least used only to describe those cases to which it can properly be applied.

CHAPTER XXI.

DISABILITIES AND DEFORMITIES OF THE FOOT.—*Continued.*

The Hollow or Contracted Foot.

Synonyms.—Non-deforming Club Foot, Talipes Arcuatus, Talipes Plantaris, Talipes Cavus.

The depth of the arch and the corresponding area of the bearing surface of the sole of the foot vary greatly in different individuals, and, although marked differences in appearance and function are possible within a normal range, yet, as a rule, the low arch is characterized by a certain relaxation and weakness of structure, while the exaggerated arch implies a corresponding contraction and loss of normal elasticity.

The hollow or contracted foot may be divided into two classes; the SIMPLE and the COMPOUND. In the first class, the simple exaggeration of the arch (talipes arcuatus) is the only change from the normal condition. In the second, the high arch is combined with a certain limitation of the range of dorsal flexion at the ankle joint (talipes plantaris—Fisher).

Etiology.—The simple hollow foot may be an inherited peculiarity. The depth of the arch may be exaggerated by the habitual use of high heels (postural equinus), or by excessive use of the calf muscle, as by professional dancers.

The compound variety, in which the hollow foot is combined with slight equinus, may be inherited also; but in most instances, its origin may be traced to a mild and transient form of anterior poliomyelitis or neuritis in early childhood. This causes temporary weakness of the anterior group of muscles of the leg, and thus a slight toe drop, followed by secondary contraction of the tissues of the sole and of the muscles of the calf. In the history of many of these patients it will be found that after recovery from scarlatina or other contagious or infectious disease, the child seemed weak or awkward. These symptoms became less marked or practically disappeared; yet a trace remained, although not of sufficient importance to call for treatment, until adolescence or adult life, when the greater strain and weight put upon the feet brought to light the latent disability. The affection may undoubtedly develop in later years as the result of neuritis, or of gout or rheumatism. It may be caused by a sprain or fracture of the ankle, and it may be a result of habitual posture to compensate for a leg shortened by injury or disease.

The exaggerated arch which is a part of a more important deformity, as of equino-varus or calcaneus, or that which is simply a part of the general deformity caused by diseases of the nervous apparatus, does not belong to the class of disability under consideration.

Symptoms.—The simple hollow foot often exists without symptoms, in fact it is often considered as a particularly well formed foot rather than a deformity. The usual complaint in these cases is that one is unable to buy comfortable shoes because the ordinary shoe does not support the arch, or because the upper leather exerts uncomfortable pressure on the dorsum of the foot. The convexity of the dorsum of course corresponds to the depth of the arch, and in many instances, the

FIG. 369.

The contracted foot of slight degree.

cuneiform bones project sharply beneath the skin, and painful pressure points or even inflamed bursæ in this locality may cause discomfort.

In the well-marked cases in which the weight is borne entirely on the heel and the front of the foot, calluses and corns often form at the center of the heel and beneath the heads of the metatarsal bones. The patient may complain of neuralgic pain about the great toe, the metatarsal arch, or in the sole of the foot. The gait is often ungraceful, as the patient walks heavily upon the heels with feet turned outward. In such cases "the ankles may be weak and turn easily." In the more advanced cases of this type, the foot may assume the position of valgus when weight is borne, so that the more noticeable symptoms are those

of the weak foot or so-called flat foot, even though the depth of the arch is exaggerated.

Contracted foot, of the more severe grade, is almost always accompanied by a certain limitation of dorsal flexion; and as the shortening of the plantar fascia is often more marked at its inner border, a slight inversion of the forefoot or varus may be present also.

When the exaggerated arch is combined with limitation of dorsal flexion the deformity becomes compound. This limitation may be very slight, or it may be well marked; and a slight degree of permanent equinus even, may be present, but so slight that it does not, as a rule, attract attention.

Fig. 370.

Contracted foot, marked.

This type of the contracted foot was first clearly described by Shaffer in 1885, under the title of "non-deforming club foot"[1] and later by Fisher, of London, as "talipes plantaris."

The symptoms are similar to those of the simple hollow foot, but they are almost always more marked. The gait is awkward and jarring, the feet being turned outward to an exaggerated degree; the patient is easily fatigued, and often complains of the weakness about the ankle and inner side of the arch, characteristic of the weak foot, and of sensations of tire and strain in the calf of the leg. The discomfort from corns, the pain referred to the metatarsal region, the great toe, and to the sole of the foot have been described already.

On examination the exaggeration of the arch is evident; and an imprint of the sole shows that the weight is borne entirely on the heel, and on the heads of the metatarsal bones which may be very prominent beneath the thickened skin, as if the subcutaneous pad of fat had been absorbed. The anterior metatarsal arch is often obliterated, and the toes are usually habitually dorsi-flexed at the first phalanges, the permanent flexion and thus pressure against the leather of the shoe being shown by a row of corns upon their dorsal surface. (Fig. 370.)

The contracted plantar fascia may be demonstrated by forcible dorsal flexion of the foot, when the tense bands, in many instances very sensitive to pressure, may be felt beneath the skin.

On testing the motion of the foot, the limitation of dorsal flexion, both of the voluntary and the passive range, will be evident. In voluntary flexion, the toes are drawn up and the tendons are plainly

[1] N. Y. Med. Rec., May 23, 1885.

seen on the dorsum, showing the effort made by the accessory muscles to overcome the abnormal resistance.

The limitations of dorsal flexion may be demonstrated in the manner suggested by Shaffer, by asking the patient to flex the feet, while standing erect with the back to the wall, when in spite of the effort made, "the feet remain glued to the floor."

Treatment.—In the ordinary form of contracted foot, as has been stated, the disability is much more marked than the deformity; and the disability is due to secondary changes in the structure of the foot, by which its elasticity is impaired. If this contraction is removed permanent relief will follow. If the simple hollow foot (cavus), or the compound type (plantaris), were discovered in early childhood, massage and methodical stretching would, in all probability, be sufficient to relieve the contraction; but as a rule no symptoms are noticed until later life. Even then, especially in the simple form, they are often slight and may be relieved by a shoe with a broad heel and a high (Spanish) arch or by a foot plate that equalizes the pressure on the sole.

In the more advanced cases of the milder type, methodical mechanical stretching of the parts by means of the Shaffer[1] "traction shoe" may elongate the tissues sufficiently to relieve the symptoms; but in the more resistant cases division of the contracted parts and forcible correction of deformity is indicated.

Operative Treatment.—The patient having been anæsthetized, a tenotomy knife is introduced beneath the skin to the inner side of the central band of fascia. This is divided by a sawing motion, and if on forced dorsal flexion other tense bands appear they are divided also. Forcible massage, with the aim of making the foot flexible and reducing the depth of the arch, is then employed. If sufficient force cannot be employed by the hands, the Thomas wrench may be used as in the treatment of club foot; the object being to elongate the foot, to remove the contraction and thus by increasing the area of bearing surface to relieve the painful pressure on the heads of the metatarsal bones. If the contraction of the tendo Achillis can not be overcome by forcible manipulation it may be divided. The foot, held in an attitude of dorsal flexion, is then fixed in a well-fitting plaster bandage, a thin board, shaped to the foot, having been incorporated in the bandage, in order that firm and even pressure may be exerted upon the sole. As soon as possible, often on the following day, the patient is encouraged to walk about, in order that the pressure of the body-weight may be utilized to flatten the foot still more, while its tissues are in a yielding condition.

The bandage may be worn for six weeks, or if the tendo Achillis has been divided until its repair is complete. A well-fitting shoe should be worn, and methodical massage, and stretching of the tissues should be continued as long as the tendency to deformity remains. By this treatment the symptoms may be relieved and in many instances, a return to the normal shape and function can be assured.

[1] N. Y. Med. Jour., March 5, 1887.

Weakness of the Anterior Metatarsal Arch.

Anterior Metatarsalgia and Morton's Neuralgia.—A peculiar spasmodic pain about the fourth toe was described by Morton of Philadelphia long before its predisposing and exciting causes were understood. For this reason a description of the symptoms may with advantage precede a consideration of the weakness of which they are usually the result.

Typical cases of Morton's[1] painful affection of the foot are characterized by a sudden cramp-like pain in the region of the fourth metatarso-phalangeal articulation.

The pain may begin as a burning sensation beneath the toe, as a sudden cramp or as a peculiar feeling of discomfort about the articulation that increases in severity until it becomes almost unbearable. At first the pain is confined to the neighborhood of the affected joint, but unless it is relieved, it radiates to the extremity of the toe to the dorsum of the foot or up the leg. In many instances the onset of the pain is preceded by the sensation of something moving or slipping in the foot; in some cases the pain may be induced by sudden movements, missteps or long standing, and in practically all the cases the pain is felt only when the shoes are worn. The frequency of the recurrent cramp varies; in some cases it is felt only at infrequent intervals; in others it practically disables the patient. When the cramp habit has been acquired, very slight causes may induce the pain, for example, a thin-soled shoe, a hot pavement, "the sticking of the sock to the foot" and the like, but, as has been stated, except in the very advanced and chronic cases, the pain is never felt except when the shoe is worn.

To relieve the pain, the patient removes the shoe, rubs and compresses the front of the foot, flexes and extends the toes and the like. After the cramp is relieved, a sensation of soreness remains, and occasionally slight swelling may appear, but in most instances there are no external signs, although the affected articulation is usually sensitive to deep pressure at all times.

The more distinctive term anterior metatarsalgia, a term suggested by Poulosson of Lyons in 1889, may be employed to include Morton's neuralgia, and similar symptoms of pain and discomfort about the anterior metatarsal arch. For in many instances, the cramp-like pain is referred to other points, for example, to several adjoining joints, or the discomfort caused apparently by direct pressure on the bones of the weakened arch may be more troublesome than the irregular attacks of neuralgic pain.

Etiology and Pathology.—In seventy-eight cases of anterior metatarsalgia in which the location of the pain was noted, it was referred to the fourth metatarso-phalangeal articulation in sixty; to the third and fourth articulation in six; to the second, third and fourth in six, and in but six was the fourth articulation free from pain. The pain is most often unilateral, or if the second foot is affected, it is usually after a considerable interval.

[1] T. G. Morton, Am. Jour. Med. Sci., Aug., 1876.

The affection is more common in females than in males. Of eighty-four cases, sixty-four were in women and twenty were in men.

Anterior metatarsalgia is not an affection of early life, the average age in the reported cases being more than thirty years. It is relatively more frequent in private than in hospital practice, and not infrequently the patients are of a distinctly nervous type. The affection is usually extremely chronic. Occasionally the symptoms may cease spontaneously, and in such instances a particular pattern of shoe usually receives the credit of the cure.

Morton considered the affection to be a painful affection of the plantar nerves due to compression or pinching by the adjoining fourth and fifth metatarso-phalangeal articulations. This compression was explained by the anatomical construction of the foot, *i. e.*, the mobility of the fifth metatarsal bone which allowed it to roll above and under the fourth, its relative shortness which allowed the head and base of the adjoining phalanx to be brought against the adjoining head and neck of the fourth bone, and finally, by the peculiar distribution of the external plantar nerve between these bones that made it or its fibers more liable to injury. This natural mobility and thus the predisposition to compression might be exaggerated by a sprain, or possibly by rupture of the transverse metatarsal ligament, or the pain might be induced by wearing tight shoes, but in many instances, no cause could be assigned. On this theory, Morton advocated excision of the head of the fourth metatarsal bone to remove the point of counter-pressure. This operation has been performed many times, but practically no pathological changes in the resected bone or in the surrounding parts have ever been discovered.

In more recent years the true significance of Morton's neuralgia and of similar pains in the front of the foot, has been made more clear by the study of the relation of weakness of the anterior transverse metatarsal arch to the symptoms. Attention was first called to this point by Poulosson of Lyons, and again by Roughton, Woodruff and others, and in a much more thorough and convincing manner by Goldthwait[1] of Boston, in 1894.

The Anterior Metatarsal Arch.—If one examines a normal foot, one notices that the two middle metatarsal bones, the second and third, are slightly longer and on a higher plane than their fellows. On the sole of the foot the arch is shown by the depression immediately to the outer side of the muscular projection of the great toe joint. When weight is borne, all the metatarsal bones are on the same plane and the arch is obliterated, but when the weight is removed, the arch reforms with a certain natural resiliency. In walking and standing, the weight is balanced on the head of the third metatarsal bone as is shown by a thickening of the skin beneath its head, but the strain on the metatarsal arch is relieved somewhat by the balancing action of the muscles about the first and fifth metatarsal bones, the inner and outer supports of the arch, and by the active assistance of the toes themselves. When

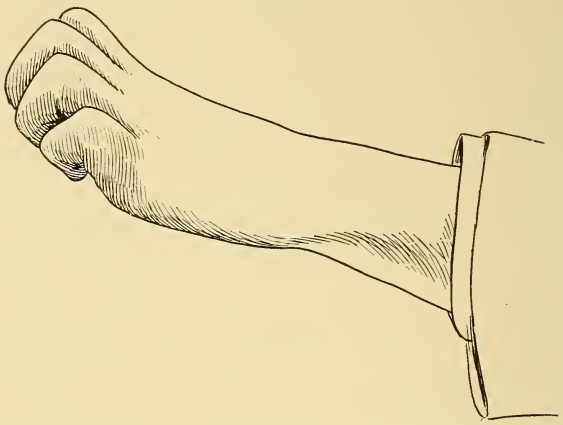
[1] Boston Med. and Surg. Jour., Vol. 131, p. 233.

the arch is weak or broken down, this natural resiliency is lost, and, in some instances, the center of the forefoot is not only depressed but it is fixed in this abnormal attitude.

In the ordinary type of depressed anterior arch, the deformity may be shown by an imprint of the foot, in which the flabby tissues of the depressed arch encroach upon the clear space representing the longitudinal arch, and obliterate what Goldthwait calls the reëntering angle to the outer side of the great toe joint, which in the normal foot indicates the highest point of the metatarsal arch. In many instances however, the imprint of the foot subject to Morton's neuralgia may be, to all intents, normal and on the other hand depression of the metatarsal arch, one of the very common results of improper shoes, may be present, yet unaccompanied by pain or discomfort.

Depression of the anterior arch, the result of the loss of the activity of the accessory supports of the arch, predisposes to pain because of

FIG. 371.



Position of the fingers corresponding to dorsi-flexion of the toes, an attitude in which lateral pressure causes pain.

abnormal pressure upon the persistently depressed articulations from beneath, and it predisposes to pain, as the writer has endeavored[1] to explain, because the metatarso-phalangeal joints of the arch, which is habitually depressed, cannot escape direct lateral compression, if it is exerted by the shoe or otherwise.

This point may be illustrated in the hand. When lateral pressure is applied, the hand is folded together and the anterior metacarpal arch is increased in depth, but if the fingers be dorsi-flexed so that it is fixed in a depressed position, then lateral compression causes great pain at all the articulations (Fig. 371); or if one finger is dorsi-flexed and the corresponding metacarpal bone is thus forced below the level of its fellows, lateral compression causes pain at the compressed joint. Or if the matacarpal bone of the little finger is made to override the

[1] N. Y. Med. Rec., August 6, 1898.

fourth, lateral pressure causes pain usually of a more acute character than at the other joints, because the opportunity for direct pressure is more favorable.[1] Finally if firm pressure is made upon one or the other side of the head of the depressed metacarpal bone of the dorsi-flexed finger in the palm of the hand, a point of sensitiveness, representing apparently the digital nerve, can be made out. The same experiments may be tried upon the foot with the same results, and it would seem to make clear the mechanism of the pain of Morton's neuralgia, and the allied forms of discomfort at the front of the foot.

Anterior metatarsalgia is in most instances the result of weakness or depression of the anterior metatarsal arch as a whole or in part, and the quality of the pain corresponds fairly to the form of weakness or deformity. If, for example, the entire arch is rigidly depressed, as in certain rheumatic affections, the discomfort is likely to be caused, in great degree, by the direct pressure of the sensitive depressed metatarso-phalangeal joints on the sole of the shoe, or if lateral pressure is exerted as well, the more acute discomfort or pain may be referred to the metatarsal arch in general. If the metatarsal arch is weakened, depressed and broadened but not rigid, the discomfort is often referred, as in the preceding instance, to the center of the arch, and this discomfort is increased, in some instances, by a painful callus representing abnormal pressure at this point. If one of the metatarsal bones falls below its fellows, the lateral pressure of a narrow shoe may cause neuralgic pain at this joint, but in many instances, in which the anterior arch is depressed the patient makes but little complaint of pain. In certain instances, more particularly those of Morton's typical neuralgia, the foot may appear to all intents normal; in such cases it may be inferred that the sharp and characteristic pain is caused by pressure applied to the over-riding fifth metatarsal bone, just as similar pain is felt if the hand is suddenly compressed while the fifth metacarpal bone is in a similar position. This theory is the more probable when one considers the symptoms; for example, the sensation of something slipping or moving, the necessity for the removal of the shoe to flex and extend the toes and to compress the foot, apparently with the instinctive aim of replacing a depressed arch, or a misplaced bone in the arch. It would also explain how the shoe may be the most direct of the exciting causes of the deformity, in that it compresses the forefoot, and throws more weight upon it by elevating the heel. If the arch is depressed or becomes depressed, or if a bone in the arch over-rides another, this compression causes the symptoms.

The Influence of the Shoe in Causing Disability and Pain.—In the etiology of pain and discomfort about the anterior arch, one must recognize the shoe, not only as the direct cause of the pain, but also as the most important of the predisposing causes of weakness of the anterior arch, of which the pain is a symptom, since it compresses the toes, lifts them off the ground by its "rocker sole," and thus, by preventing their normal function, throws additional strain and pressure

[1] This anatomical peculiarity is well known to school boys.

upon the arch. In fact in a very large proportion of feet that are supposed to be normal in appearance and functional ability, the toes are habitually dorsi-flexed in a claw-like attitude, that shows entire disuse of their function both as a support and in progression. Women wear shoes with narrower soles and higher heels than men, and this seems the most reasonable explanation of the fact that they are more subject to the affection.

The shoe also predisposes to habitual elevation of the fifth metatarsal bone, because this bone almost invariably overhangs the narrow sole, so that the fourth metatarsal bone becomes the outer support of the arch, and is almost always found to be on a lower level than the adjoining bones ; a fact which, together with the natural mobility that may have become increased by injury or otherwise, may account for the location of the pain at this point in the majority of cases. Although in certain instances a neuritis may follow direct injury, yet this assumption is not at all necessary to explain the symptoms. Nor is it likely that the peculiar distribution of the nerves at this point has any direct influence on the pain, for the nerve supply of all the joints and all the toes is practically identical.

Other Factors in the Etiology.—Besides the general effect of the shoe, and the possible influence of inherited predisposition to the affection, which seems evident in certain cases, or of weakness or direct injury of the anterior arch, one recognizes among the causes or complications of anterior metatarsalgia, weakness of the longitudinal arch or flat foot, which may be combined with a depression of the anterior arch. Less often the longitudinal arch may be exaggerated in depth and the dorsal flexion of the foot may be limited by a shortened tendo Achillis, thus more pressure is brought upon the front of the foot. In these cases, the pain may be increased by corns or calloused skin beneath the depressed bones and in many instances the discomfort of the depressed arch of the ordinary type is, in great part, caused by a sensitive corn or fibroma at the point of greatest depression, and the patient may be entirely relieved by its removal. (See contracted foot.)

Although the symptoms of anterior metatarsalgia may be explained in most instances by the primary effect of improper shoes, by weakness and abnormality of the foot itself, and by the local sensitiveness of the parts that are continually subjected to strain pressure and injury, yet in some instances the symptoms can be explained only by local neuritis ; in others, they are aggravated by gout or rheumatism or general debility, and as has been stated in a large proportion of the cases the patients are of a distinctly nervous type.

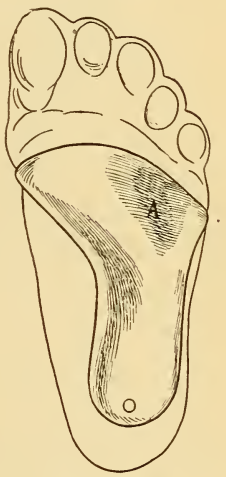
Treatment.—The most important local treatment is to provide the patient with a proper shoe. This shoe must be of proper shape with a thick sole, so broad that no lateral compression of the toes is possible, with a high arch, as suggested by Gibney, in order to remove a part of the pressure from the heads of the metatarsal bones, and a low heel.

As an immediate treatment, a firm bandage about the metatarsal region, as suggested by Morton, may aid in supporting the metatarsal

arch, or better, adhesive plaster strapping may be applied about the metatarsus. Beneath or slightly behind the affected joint or the depressed arch, a pad, preferably an oval piece of sole leather, about one inch by three-quarters of an inch in size and one-quarter in thickness with bevelled edges, may be fixed to the sole of the foot with adhesive plaster, so that depression of the arch or overriding of the adjoining bones may be prevented. This pad, suggested by Poulosson and Goldthwait, almost always relieves the pain, and when the exact place has been ascertained, it may be fixed to the sole of the shoe.

As a rule, however, a metal support will be found to be more comfortable and more efficient. This may be constructed of light steel (19 gauge) upon a plaster cast of the sole of the foot, of which the natural depressions, indicating the anterior and the longitudinal arches, have been somewhat exaggerated. The anterior extremity of the brace is made as wide as the foot, and extends forward slightly beyond the metatarsophalangeal articulations. The brace serves to support the anterior as well as the longitudinal arch. If there is slight depression of the longitudinal arch it may be further corrected by raising the inner border of the heel and sole of the shoe, but if it is more pronounced a flat foot brace (Fig. 365) may be employed, whose anterior extremity is modified to support the metatarsal arch, as is shown in Fig. 372. If, on the other hand, the arch is exaggerated and if dorsal flexion is limited, treatment with the aim of relieving this deformity will be necessary, as described under "contracted foot." When the immediate symptoms of pain and local discomfort have been relieved, the patient must endeavor to strengthen the natural supports of the arch by proper functional use of the foot, and by regular exercise of the muscles, more especially by methodical forced flexion of the toes, as this motion elevates the anterior metatarsal arch. (Fig. 373.)

Fig. 372.



A brace for anterior metatarsalgia. A indicates a point beneath the fourth metatarso-phalangeal articulation which is elevated in order to support the depressed articulation.

If the anterior arch is rigidly depressed as in some instances, its flexibility must be restored by manipulation or by forcible correction under anæsthesia before a brace can be applied. If the symptoms are very acute, and particularly if they have followed direct injury, the parts should be placed at rest and the anterior arch should be elevated and supported by a properly applied plaster bandage.

In chronic and resistant cases, or when conservative treatment cannot be applied, resection of the neck and head of the metatarsal bone at the seat of pain may be performed as advocated by Morton. The operation is very simple. An incision is made over the dorsal surface of

the joint, and the bone is separated by bone forceps. The toe is not, as a rule, removed, but after the operation it slowly recedes between the adjoining metatarso-phalangeal joints, causing a rather noticeable deformity. The operation is, as a rule, successful, but in the majority of cases it is unnecessary.

The general condition of the patient should of course receive attention, and local applications, electricity and the like, may be of benefit in special cases.

A SENSITIVE CALLUS beneath the arch may require removal, and in certain cases its removal may be the only treatment required other than an improved shoe. But as a rule, the cause of the callus is habitual depression of one or more of the metatarso-phalangeal articulations, so

FIG. 373.

Exercise for the weakened metatarsal arch.

that cure can only be assured by supporting the arch and by strengthening its natural supports in the manner already described.

Woodruff[1] described a case of what he called "incomplete luxation of the metatarso-phalangeal articulation" in which the symptoms, practically identical with those of Mortion's neuralgia, are ascribed to an upward displacement of the proximal phalanx of the fourth metatarsal bone.

Another writer, Guthrie,[2] described a case in which intense pain followed over-extension of the third phalanx upon the second. Such cases are extremely uncommon and need only be mentioned.

Achillo-Bursitis.

Synonyms.—Achillodynia, Achillo-bursitis Anterior, Retro-calcaneo Bursitis.

Under the title of achillodynia, Albert,[3] of Vienna, in 1893 called particular attention to an affection characterized by pain and tenderness about the insertion of the tendo Achillis, symptoms usually

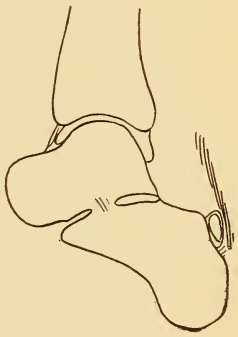
[1] N. Y. Med. Record, Jan. 18, 1887.
[2] Lancet, March 19, 1892.
[3] Wien Med. Presse, Jan. 8, 1893.

caused by irritation or inflammation of the small bursa lying between the insertion of the tendon and the bone. (Fig. 374.)

Etiology.—In the acute cases, the cause of the bursitis often appears to be a strain of the tendon or direct injury, as the symptoms appear immediately after running or jumping or after a fall, sometimes after a long walk or bicycle ride.

In the subacute cases, the symptoms may begin almost imperceptibly, so that it may be impossible to assign a direct cause other than the pressure of the shoe, aggravated it may be, by an exostosis of the os calcis beneath the insertion of the tendon or by concretions within the bursa. In many instances rheumatism, gout, gonorrhœa or one of the infectious diseases, appear to be associated, directly or indirectly, with the onset of the symptoms, or the bursa may be secondarily involved in tuberculous disease of the os calcis.

Fig. 374.



Bursa between the tendo Achillis and the os calcis.

Symptoms.—In a typical case, pain is felt in the back of the heel at the insertion of the tendon; the pain is increased by use of the foot, and particularly by the attitudes in which the strain on the part is increased, as, for example, in descending stairs. There is also tenderness on pressure about the back of the heel on either side of the insertion of the tendon. In most cases, a slight swelling, often more prominent on the inner than the outer side of the tendon, indicates the situation of the bursa.

In the chronic cases, the enlargement of the bursa is very noticeable, and in addition, the entire posterior aspect of the heel often appears to be thickened. This is due probably to the secondary irritation about the fibrous expansion of the tendon and the adjoining periosteum. In many cases, the symptoms are pronounced; pain is often felt in the bottom of the heel or it radiates up the back of the leg. The patient, unable to use the power of the calf muscle, everts the foot in walking, thus subjecting the arch to over-strain, so that the symptoms of the weak foot are often added to those of the original trouble. Not infrequently however the two affections may be associated from the beginning in one or the other foot. The patient complains much of stiffness and weakness at the ankle and sub-astragaloid joints. In the acute cases, or in acute exacerbations there is usually burning and throbbing pain characteristic of acute inflammation, but in the subacute form the pain is slight, and is troublesome only after over-exertion.

Pathology.—The pathological changes do not differ from those found in and about other bursæ under similar conditions. In the mild cases the lining membrane is simply congested and the cavity contains serous fluid. In the chronic cases, the walls are much thickened,[1] the lining membrane is fringed and reduplicated; the contents

[1] Rössler, d. Z. f. Chir., Bd. 42, 1 and 3.

are semi-solid, and sometimes calcareous masses are present. Similar changes are found however, in the bursæ of apparently normal subjects, so that the condition of the bursa may not always correspond to the character of the symptoms. Suppuration of the sac occasionally occurs, and it may be the seat of tuberculous or syphilitic disease. In cases of long standing, the parts adjoining the bursa, the expansion of the tendon and the periosteum become thickened so that the bone appears to be increased in breadth and may actually become so.

Treatment.—When once established, the affection is usually of a very chronic nature, as is explained by the strain to which the sensitive part is subjected by the use of the foot. It is therefore important to apply efficient treatment at the beginning of the affection if an opportunity is afforded. Efficient treatment implies absolute rest, and in all cases of any severity, particularly those of acute onset, a well-fitting plaster bandage should be applied to hold the foot slightly inverted and at a right angle to the leg. This should be worn until all symptoms have subsided. In very mild cases, following immediately on a strain or over-use, simple rest with the application of heat, massage, and pressure, may be efficient. And in the subacute cases, the symptoms may be relieved by the application of a long broad band of adhesive plaster, from the toes over the back of the heel to the upper third of the calf, the foot being slightly plantar flexed. This is firmly fixed by narrow strips of plaster about the metatarsus, the heel and the calf. By this means pressure is exerted upon the bursa, and much of the strain is removed from the tendon.

In persistent cases, a brace may be used with advantage, for the purpose of preventing strain upon the tendon. Two lateral uprights with a calf band and padded strap that crosses the upper third of the leg are attached to the shoe, provided with a stop joint at the ankle as used in the treatment of paralytic calcaneus to prevent dorsal flexion. (See talipes.) As the patient is usually sensitive to jar, the heel of the shoe should be replaced by one of thick rubber. In connection with the brace, the stimulation of the cautery and the pressure of the adhesive plaster strapping seem to hasten the absorption of the effusion in and about the bursa. If weakness or depression of the arch is present, as a result of the disability or combined with it, a foot plate should be applied (see page 525), and general affections, with which the disability is sometimes associated, should of course receive attention.

Operative Treatment.—In chronic cases, in which the symptoms are not relieved by treatment, the enlarged bursa may be removed by an incision on one or both sides of the tendon. A plaster bandage is then applied and is continued until the symptoms have subsided. Operative treatment is of course indicated in acute suppurative inflammation, in tuberculous disease, or if an exostosis beneath the bursa or concretions within the sac are present, as shown by the X-ray photograph.

Achillo-Bursitis Posterior.

Tenderness, pain and swelling at the back of the heel may be due to inflammation of the small superficial bursa that lies between the tendon and the skin. The cause is usually injury or the pressure of the shoe. The symptoms resemble somewhat those of achillo-bursitis anterior, but the swelling is more superficial, and the pain is caused by direct pressure rather than by tension on the tendo Achillis. In the ordinary case, removal of the pressure will at once relieve the symptoms, but if the discomfort is considerable, a plaster bandage may be worn for a week or more.

Sensitive points at the back of the heel are usually caused by the pressure of the shoe; in rare instances, prominent points, or exostoses of the os calcis are present, that may require special protection or removal.

Strain of the Tendo Achillis.

Not infrequently, and usually as the result of strain or over-use of the foot, patients complain of symptoms similar to those of achillo-bursitis, but on examination, one finds that the pain and sensitiveness are referred to the tendon itself. There is no swelling at its insertion, or pain on lateral pressure on the os calcis. The sensitive area may be as high up as the junction of the tendon with the muscle, and again, the mid-point of the tendon seems most painful.

The cause in some cases may be a direct strain of the tendon or of the muscular fibers near its origin, or inflammation of its fibrous covering due probably to the same cause. The treatment is similar to that of the milder type of achillo-bursitis, by the adhesive plaster strapping, by rest, and later, by massage. Recovery is usually rapid.

Painful Heel—Calcaneo-Bursitis.

Pain referred to the bottom of the heel, and sensitiveness to pressure on standing, are common symptoms of the weak or flat foot. Pain at this point may be one of the symptoms of achillo-bursitis also. In rare instances, the painful point is clearly localized and is confined to a small area in the neighborhood of the inner tuberosity of the os calcis. The cause of the symptoms, in such cases, may be an inflamed bursa lying between the periosteum and the fatty tissue of the heel. Such bursæ may contain hard substances or even a fasciculated neuroma.[1]

More general pain and tenderness referred to the heel, is often caused by the direct pressure and bruising of the tissues by over-use of the feet.

Treatment.—Treatment must be directed to the condition of which the pain is a symptom, and, as has been stated, it is most often one of the symptoms of the weak or broken-down arch. If the tender point is

[1] Brousses & Berthier, Revue de Chir., Aug., 1895.

localized, and if the pain is increased by jars, a thick rubber heel combined with an inner sole, so cut out as to remove the direct pressure on the sensitive point, will often relieve the symptoms. In persistent cases, in which the sensitive point is distinctly localized, operative intervention for the removal of the bursa is indicated. The tissues of the heel may be turned back in a horseshoe-shaped flap which will allow a thorough examination of the affected parts.[1]

Sensitiveness due to direct contusion, or bruising of the tissue caused by over-use, must be treated by rest and by change of occupation, unless a reduction of the body-weight or improvement in attitudes relieve the symptoms.

Plantar Neuralgia.

Synonym.—Plantalgia.

Pain referred to the sole of the foot, and sensitiveness to pressure on the plantar fascia, are usually symptomatic of the contracted foot (cavus); less often such symptoms accompany the weak or broken-down arch.

Pain, tenderness and thickening of the fascia sometimes follow injury (rupture of the fascia),[2] and a similar condition has been described by Franke as one of the sequelæ of influenza.[3]

Treatment.—Pain in the sole of the foot, symptomatic of the contracted or of the weak foot, may be relieved by the treatment of the conditions of which it is a symptom. In the rare instances in which the fascia is itself injured or diseased, local rest, as afforded by the plaster bandage, is indicated until the acute symptoms have subsided.

Erythromelalgia.

Wier Mitchell[4] has described a series of cases characterized by attacks of heat, redness, pain and often swelling of the soles of the feet. Of 27 cases all but two were in women, many of whom were of a nervous or neurasthenic type. The affection appears to be a form of vaso-motor disturbance. Disturbances of the circulation and burning pain in the soles of the feet are common symptoms of the weak foot and of allied affections, but simple erythromelalgia unaccompanied by disability of this character is uncommon. It deserves mention however as a possible explanation of symptoms in obscure cases.[5]

Hallux Rigidus.

Synonyms.—Hallux Flexus, Painful Great Toe.

Hallux rigidus is a painful affection of the great toe joint, characterized by restriction of motion, particularly of the range of dorsal flexion.

[1] Duplay, Clin. Chir. de l'Hotel Dieu. Série, 1897.
[2] Lederhose, Verhand. der Deut. G. für Chir., XXIII., Kong, 1894.
[3] Archiv f. Klin. Chir., Bd. 49, 1895.
[4] Am. Jour. Med. Sci., Vol. 76, 1878.
[5] Prentiss, Trans. Am. Ass'n Physicians, Vol. XII., 1897, p. 303.

In advanced cases, the first phalanx may be slightly plantar flexed together with its metatarsal bone, hence the name hallux flexus, applied by Davies-Colley, who first described the affection.

The restriction of motion may be complete, as implied by the term rigidus; the joint appears unduly prominent or enlarged, usually slightly congested, and pressure or forced movement causes pain.

The symptoms of which the patient complains are a burning or throbbing pain in the joint, increased by standing and particularly by walking, because of the enforced movement of the stiff and painful articulation. In many cases there is no actual deformity of the joint or other change; the restriction of motion is much less, and the symptoms are correspondingly slight.

Etiology.—Typical hallux rigidus is most common in adolescence, and it is very often associated with the weak or broken-down foot. In such cases, the toe is crowded into the narrow part of the shoe, and is thus subjected to lateral and to longitudinal pressure as well as to the additional strain, that the attitude, characteristic of the weak foot, throws upon it. In some cases the habitual plantar flexion of the toe may be the result of an instinctive effort to support the weak arch (hammer toe flat foot—Nicoladoni). In other instances hallux rigidus is caused directly by traumatism; as by stubbing the toe, by kicking a hard object, or by other strain or injury. The affection appears to be, primarily, a form of periarthritis, caused by injury or pressure. The restriction of motion is in part due to muscular spasm, and in part to the irritative and accommodative changes in the ligaments and tendons. In more advanced cases changes in the cartilage and shape of the articulating surfaces, due to disuse of function, and to pressure and friction, may be present.

Fig. 375.

The dotted outline shows the shape of the steel splint that may be inserted in the sole of the shoe for hallux rigidus.

Treatment.—If the rigid and painful joint is not associated with the weak arch, it may be relieved by providing the patient with a proper shoe, which exerts no pressure on the sensitive part. Motion of the joint may be lessened by increasing the thickness of the sole, or if necessary, it may be entirely restricted by the insertion of a brace of tempered steel between the two layers of the sole, as shown in the diagram. If, as in some instances, the rigid and flexed joint is associated with rigid flat foot, both deformities may be over-corrected, under anæsthesia, and retained in this position by the plaster bandage, as a preliminary treatment.

If the milder type of painful joint is associated with the ordinary weak foot, the treatment of the latter condition will usually relieve the symptoms. In this class, particularly among the poorer patients, the shoe may be raised on the inner side, and the sole stiffened by means of the wedge-shaped sole recommended by Thomas, as already described in the treatment of the weak and flat foot. If painful motion

is restricted and the exciting causes of the disability are removed, relief of the symptoms is usually immediate. In the chronic cases, in which the pathological changes are more advanced, excision of the joint may be necessary.

Painful Great Toe Joint in Older Subjects.

A similar condition of the joint is sometimes found in older subjects. In many instances the foot is well formed, and the restriction of motion in the joint is very slight; yet forced dorsal flexion causes pain and long standing or walking causes much discomfort, particularly a dull ache in the joint and sharp neuralgic pain referred to the terminal phalanx. In some cases, the onset of the symptoms may be ascribed to a long walk, or "mountain climb," in others to wearing tight shoes, and in some instances, no definite cause can be assigned by the patient. In such cases, the symptoms are often supposed to be evidences of gout or rheumatism but although the local discomfort may

FIG. 376.

Simple congenital varus, adduction without supination—a form of pigeon toe.

be aggravated by a predisposition to such diseases, yet no relief can be obtained by medication unless it is combined with the local treatment that has been described in the preceding section. The relief afforded by such treatment alone, proves, in many instances, that the affection is purely local in its character. (Fig. 375.)

As has been mentioned, pain referred to this joint is a common symptom of the weak foot, and of the contracted foot as well. It is also caused by simple pressure on the joint, and by the use of improper shoes which force the toes into the abducted position.

Pain directly beneath the great toe, and sensitiveness to pressure about the sesamoid bones seem to indicate an inflammation of the ten-

don sheath or local periarthritis. If the discomfort is persistent, the sesamoid bones may be removed. As a rule, such symptoms occur only in combination with pain or deformity of the great toe joint.

Hallux Varus.

Adduction of the great toe is not infrequent in infancy, and it may be associated with a slight degree of varus deformity. (Fig. 376.) The peculiarity attracts the mother's attention because of the difficulty of drawing on the socks. In many instances the muscles seem abnormally developed, and the toe appears to be somewhat prehensile in its movements.

Treatment.—The abnormal mobility may be checked by inclosing the toes with a narrow strip of adhesive plaster; in any event the ordinary shoe may be depended upon to correct any residual deformity of this character. If the adducted toe is combined with varus, it represents a slight degree of club foot that must be corrected in the ordinary manner. (See talipes.)

Pigeon Toe.

Congenital hallux varus forms one variety of what is known as pigeon toe, or the habitual turning in of the feet in walking. The inward rotation may be due also to bow legs, or it may be an effect of congenital talipes that remains after the cure of the deformity, or of the exceptional variety of coxa vara, in which the depressed necks of the femora are turned forward. In most instances pigeon toe in childhood is symptomatic of weakness either of the arch of the foot or of the knees (genu valgum). In such cases, it is a conservative effort of nature that serves to check further deformity, and it needs no treatment other than that which may be applied to the weakness of which it is a symptom.

In the exceptional cases, in which the posture is not symptomatic of weakness or the effect of deformity, the sole of the shoe may be raised slightly on the outer border. This will correct the attitude in the milder type, if combined with instruction and training. In rare instances, the in toeing seems to be caused by limitation of the range of outward rotation at the hip joints, a restriction that must be overcome by systematic stretching of the contracted parts. In these and in the more obstinate cases of the simple type apparatus may be applied, similar to that used in the after-treatment of congenital club foot, to hold the feet in the proper attitude. (Fig. 377.) It must be borne in mind that the proper attitude of the feet is one of parallelism, not of outward rotation, and that slight pigeon toe will as a rule correct itself as the child grows older.

Hallux Valgus.

Hallux valgus is a deformity in which the great toe is turned outward to an exaggerated degree. Outward deviation of the toe is so common, owing to the use of improper shoes, that it is not recognized

as a deformity, at least from the popular standpoint, unless the joint appears to be much "enlarged" forming a so-called bunion.

Hallux valgus is practically a partial dislocation of the phalanx upon the metatarsal bone. In well-marked cases, the metatarsal bone is adducted or turned inward so that an abnormal interval separates its head from its fellows, while the phalanx is displaced outward and articulates only with the outer condyle. The angle thus formed, or more properly the inner condyle of the adducted metatarsal bone, makes the prominent or "outgrown" joint. (Fig. 382.) This projects sharply beneath the skin, and is exposed to injury and to the pressure of the shoe; thus a bursa develops beneath the skin, while a corn or callus forms on its superficial surface. The projecting bone, covered by the irritated bursa and the thickened skin, makes up the bunion.

Fig. 377.

An appliance constructed of leather bands and elastic webbing for the correction of in toeing. Name of the inventor unknown.

In many instances the other toes are displaced outward, in the direction corresponding to that of the great toe, or this may be rotated on its long axis and lie above or beneath its fellows.

Pathology.—The pathological changes are such as usually follow deformity, disuse of function, and injury. The cartilage on the exposed condyle atrophies, the sesamoid bones, together with the flexor tendon, are displaced outward, the tissues on the outer side undergo accommodative shortening, while those on the inner side are correspondingly lengthened and attenuated. The surface of the bone beneath the irritated periosteum is often roughened and irregular, and exostoses may form about the condyle, and thus aggravate the effects of the external pressure.

Etiology.—The deformity is the direct effect of shoes that are too narrow and of improper shape, and in some instances too short for the foot, so that the great toe is subjected to lateral and longitudinal pressure. The deforming effect of the shoe is increased if the arch is weak, so that the toe is forced forward into the narrower part of the shoe when the foot is in use. The deformity may be increased by injury, or by the changes that follow gout, rheumatism, or rheumatoid arthritis, and in rare instances, the distortion may be the direct result of such dis-

eases; but all other factors are of slight importance when compared to the deforming influence of the ordinary shoe. The deformity begins at a very early age; it advances more rapidly during adolescence, but the symptoms do not often become troublesome until later years. Both toes are affected, as a rule, although the deformity and its accompanying symptoms are usually more marked on one side.

Symptoms.—As has been stated, the slighter grades of deformity are not recognized as such, and it is usually because of the pain due to the irritating corn or bursa, and incidentally, because of the outgrown joint, that the patients apply for treatment.

Treatment.—The symptoms in the ordinary cases may be relieved by providing a proper shoe, by which pressure on the joint is completely removed. (Figs. 361, 378.) The sole should be strong, and it should be slightly thicker along the inner side so that the sensitive joint may be inclined away from the upper leather. In cases in which the deformity is not far advanced, the use of a proper shoe that allows space for an improved position of the great toe, combined with methodical manual correction of the deformity, and exercise of the disused muscles, while the toe is guided in the proper directions by the fingers, will relieve the symptoms promptly and practically cure the deformity.

Several forms of correcting braces have been devised, to be worn during the day, a digitated stocking and special shoe being, of course, necessary. But in the class of cases that can be successfully treated by mechanical correction, few patients will be found who are sufficiently interested in the cure of the deformity to submit to the slight discomfort caused by a brace.

A simple device for holding the toe in an improved position is the Holden toe post, recommended by Walsham and Hughes. This is a thin piece of metal so fixed in the front and inner side of the sole of the shoe that it separates the first and second toes from one another and holds the former in an improved position. It of course necessitates a special shoe and a special shoemaker to fit it in its proper place.

Operative Treatment.—In cases in which the deformity is of long standing, and in which the projecting condyle or the exostoses make protection of the sensitive joint difficult an operation is indicated. The primary object of the operation is to remove the projecting bone. This may be accomplished by a slightly curved incision about the inner aspect of the condyle, the center being below the joint, so that the scar will not be subjected to pressure. The flap of skin is raised, the periosteum and part of the capsule are lifted from the bone, and the entire condyle is removed with a chisel, so that the surface is made perfectly smooth. Contracted tissues that resist a corrected position of the toe are stretched or divided, and the wound having been closed with sutures, a plaster bandage is applied about the foot and toe. This may be worn with advantage for several weeks, when the parts will have become less sensitive, and the toe will have become accustomed to an improved position. The after-treatment is the same that has been described for the ordinary cases.

In most instances, it is well to remove the thickened bursa from beneath the flap of skin. As minor points in the operation, the removal of the displaced sesamoid bones has been advised; and the tendency to recurrence of deformity may be checked according to Weir,[1] by dividing the tendon of the extensor proprius pollicis, and sewing its proximal end to the periosteum of the inner border of the base of the first phalanx.

Cuneiform osteotomy of the metatarsal bone is an effective operation if the base of the wedge includes the projecting bone. Resection of the head of the metatarsal bone is as a rule unnecessary, but it may be indicated if the deformity is extreme.

Hallux valgus is often combined with the weak or broken-down arch; in such cases the foot must be supported by a properly fitted brace. This is of especial importance after treatment by operation.

Bunion.—As has been stated, the discomfort of hallux valgus is caused in great part by the irritated bursa and the over-lying corn. These symptoms may be relieved by rest and by hot applications. Afterwards the callus or corn may be removed, and the sensitive bursa may be protected by a bunion plaster. Operative treatment should be deferred until after the acute symptoms have subsided.

Hammer Toe.

Hammer toe is a contraction of one of the toes, usually of the second, in which the first phalanx is dorsi-flexed, the second plantar flexed, while the third may be flexed or extended. The contracted toe is over-lapped by its fellows; its projecting dorsal surface is subjected to the pressure of the upper leather of the shoe, and the terminal phalanx, forced against the sole of the shoe and compressed by the adjoining toes, becomes flattened into a club or hammer-like form. The nail is distorted and often "ingrown"; in most cases a corn or callus forms upon the extremity of the toe and a small bursa and corn over the projecting knuckle, on the dorsal surface. A third corn or callus is often found beneath the head of the metatarsal bone which has been forced downward by the flexion of the toe.

Hammer toe is usually bilateral; it may be congenital, and hereditary even, but it is usually acquired, the effect of shoes that are too short and too narrow. The second toe is deformed most often because it is the longest, and because it suffers most from the lateral compression as well. The deformity begins, as a rule, in early childhood, when, the growth of the foot being rapid, it is more likely to suffer from the effects of outgrown shoes, and socks as well.

Symptoms.—The symptoms are practically those of the corns or blisters caused by the pressure of the shoe, but they are often sufficiently troublesome to interfere seriously, not only with the comfort but with the ability of the patient.

Treatment.—The resistance to the rectification of the deformity is

[1] Annals of Surgery, April, 1897.

caused by the accommodative changes that follow habitual malposition. In cases of long standing, all the tissues may be involved in the contraction, of which the most resistant are the shortened capsular and lateral ligaments of the first inter-phalangeal joint.

The congenital hammer toe of the infant may be treated by manipulation. When the resistance is overcome, the toe may be held in proper position by narrow strips of adhesive plaster passed over and under it and about its fellows. In older children a digitation in the stocking will often hold the toe in place if the deformity is slight and if a wide shoe is worn. In adult cases, in addition to the manipulation and shoe, a retention apparatus, in the form of a light plantar splint, or stiffened inner sole to which the toe can be attached, should be worn. If the deformity is more resistant, the toe may be straightened by force, aided, if necessary, by the subcutaneous division of the contracted ligaments ; but in advanced cases, the most effective treatment is resection of the joint. Sufficient bone should be removed to allow the correction of the deformity, or in case of its recurrence, to prevent the projection of the joint above its fellows. By this operation permanent relief may be assured.

Over-lapping Toes.

Over-lapping toes are very common among adults, owing to the pressure of the narrow shoe ; and not infrequently such deformity is seen in infancy and is apparently congenital. Deflected or deformed toes may be treated in infancy by manipulation, and by support with strips of adhesive plaster in the manner described. In childhood exercise and proper shoes will usually correct acquired deformity. In older subjects, an inner sole somewhat like a sandal, to which the toes may be attached by bands of tape, may be employed if the deformity is considered by the patient of sufficient importance to demand treatment.

Exostoses of the Foot.

Simple exostoses of the foot, as distinct from those that are due to disease, as for example, to rheumatoid arthritis, are, in most instances, caused by the pressure upon a projecting bone of a somewhat deformed foot. The common examples are the hypertrophy of the scaphoid, often seen in flat foot of young children, the projection of the cuneiform bones on the dorsum of the hollow or contracted foot, the enlargement of the internal condyle of the first metatarsal bone complicating hallux valgus and the exostoses of the os calcis in achillo-bursitis. As a rule, the treatment of the deformity of the foot and the removal of pressure will relieve the symptoms without other treatment. Operative removal may be required in exceptional cases.

Displacement of the Peronei Tendons.

Permanent displacement of these tendons forward of the malleolus, is not uncommon as a result of paralytic deformity, particularly ta-

lipes calcaneus, and in such instances it gives rise to no symptoms. Displacement of one or both of the tendons, or rather a laxity of their attachments, that allows an occasional displacement or slipping from the groove behind the malleolus, may result in serious disability, because of the pain that follows the displacement, and because of the weakness and insecurity of which the patient usually complains.

The cause of the laxity of the tissues that allows displacement in feet otherwise normal, may have been injury, but as the affection is often bilateral, the predisposition may be congenital.

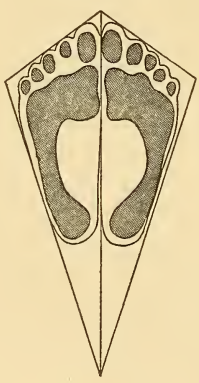
Treatment.—If the displacement is recent, as when it follows injury, the tendons should be replaced and the foot should be fixed in a plaster bandage until repair has taken place. If the displacement is habitual, a brace may be applied to restrain those motions at the ankle that induce it. In the chronic cases, an operation with the aim of fixing the tendons by deepening the groove in the malleolus, or by suturing the displaced sheath in its normal position, may be indicated. If on examination the cause of the displacement appears to be a shortening of the tendon, it may be divided and lengthened in the ordinary manner. (Fig. 241.)

Shoes.

The shoe, as a factor in the etiology of deformity and disability, has been mentioned several times in the preceding pages, but it is a subject of such importance that it would seem to call for special consideration.

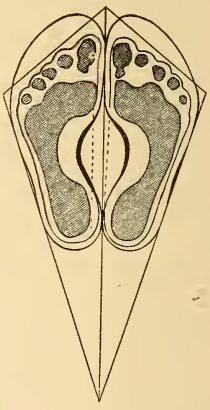
The object of the shoe is to cover and protect the foot, not to deform it or to cause discomfort; therefore, the one should corre-

Fig. 378.



Normal feet.

Fig. 379.



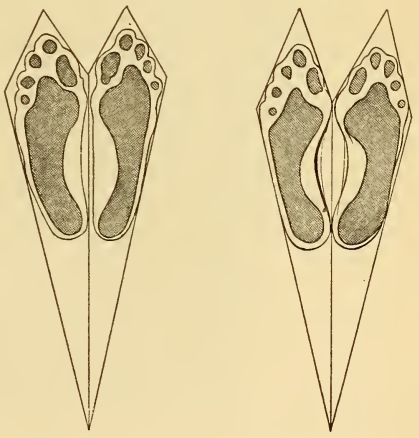
Proper soles for normal feet.

spond to the shape of the other. If the feet are placed side by side, the outline and the imprint of the soles will correspond to the accompanying diagram. (Fig. 378.) The outline demonstrates the actual size and shape of the apposed feet, emphasized by enclosing

them in straight lines. Thus, each foot appears to be somewhat triangular, being broad at the front and narrow at the heel. The imprint shows the area of bearing surface, and owing to the fact that but a small portion of the arched part of the foot rests upon the ground, it appears to be markedly twisted inward. The sole of the shoe, if it is to enclose and support the bearing surface, must also appear to be twisted inward in an exaggerated right or left pattern. It will be straight along the inner border to follow the normal line of the great toe, and a wide outward sweep will be necessary in order to include the outline and thus to avoid compression of the outer border of the foot. (Fig. 379.)

This demonstration of the true form of the foot is almost an indispensable preliminary to an intelligent discussion of the relative merits of shoes, and indeed, it is somewhat of a revelation to those who have thought of the foot only as it has been subordinated to the arbitrary and conventional standard of the shoemaker. The ideal, or shoemaker's foot, upon which lasts are fashioned, is much narrower than the actual foot; the great toe is not a powerful movable member, provided with active muscles, but is small and turns outward, so that the forefoot is somewhat pyramidal in form and turns upward as if to avoid the contact with the ground. This imaginary foot, drawn after the shape of the ordinary last, appears in the diagrams. (Figs. 380, 381.) Upon it the sole of the shoe has been indicated, to contrast it with the shape of that necessary to include the outline of the normal foot. The actual foot is thus compressed laterally by the shoe until the stretching of the leather, during the "breaking in" process, allows it to overhang the sole. The great toe is forced outward, and, with its fellows, is compressed, distorted, and lifted off the ground by the rocker-shaped sole (Fig. 383), so that normal function is reduced to the smallest limit. Thus, the foot, according to the age at which the reshaping process is begun and the constancy of the application, gradually approaches the ideal and fits the shoe. (Fig. 382.)

Fig. 380. Fig. 381.



Shoemaker's feet. Shoemaker's soles.

This remodelling, however, is often accompanied by such discomfort that the individual rebels and wears a shoe with a square toe, which, from the conventional standpoint, is supposed to show a meritorious effort to follow nature. But the demonstration of the actual foot makes

it evident that it is a properly shaped sole, which serves as a support, not the part which projects beyond the foot, that is of importance. If the shoe with the square toe is wider, and straighter on the inner side than another with a pointed toe, it is in so far an improvement. But, as a matter of fact, one of the worst types of shoe provided for children, in shape very like the old-fashioned coffin lid, owes its popularity to the square toe. The same comment may be made on the so-called

FIG. 382.

Skiagram of a foot modeled to fit the shoe, illustrating the etiology of hallux valgus.

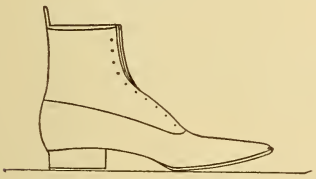
"common sense" shoe, which is well named, since it may be assumed that a properly shaped shoe is an evidence of uncommon sense.

The object of the heel is to make walking easier by inclining the body somewhat forward. The high narrow heel is an insecure support, and aids deformity by throwing more strain upon the forefoot and pushing it forward into the narrowest part of the shoe. The heel is of course unnecessary in childhood, and should not be worn, since it

limits the necessity for, and therefore the use of, the normal range of motion at the ankle joint. The ordinary shoe, by restricting the functional use of the foot, favors awkwardness and improper attitudes. It compresses the toes, and is directly responsible for corns, bunions, ingrown toenails, and deformities, and indirectly it causes or aggravates nearly every weakness to which the foot is liable. This assertion does not need support of argument, since in some degree it has been proved by the personal experience of every shoe wearer.

The shape of the proper shoe corresponding to the undistorted foot has already been demonstrated. (Fig. 379.) The sole should be thick enough for protection, but not so rigid as to limit normal motion; it should follow the imprint of the foot, projecting somewhat beyond the outline of the toes; it should be flat (Fig. 384), and the upper leather

FIG. 383.



The rocker sole.

FIG. 384.

The flat sole.

should be capacious. In other words, the front of the shoe should be designed to allow and to encourage functional activity, the slight adduction of the great toe and the alternate expansion and contraction of its fellows, as may be observed in the barefoot child. Thus the arches may be supported, and the weight and strain properly distributed. The heel should be broad and low. Most adult feet are more or less deformed, and therefore better suited by an improved than by a perfect shoe. Of this class, what is known as the wide Waukenphast pattern is the best. In selecting the better from the worst of the "ready made" shoes, the breadth of sole, the angle of outward deviation of the soles, when the two are placed side by side, and the capacity of the upper leather, must be the determining points. The most effective work for reform can be accomplished by providing proper shoes for children, and thus preventing deformity. The inspection of children's feet shows that atrophy and compression begin at a very early age, and if protection might be assured during the period of rapid growth, serious distortion might be prevented.

Socks.—Although of far less importance than the shoes, the socks worn by children deserve special mention as a factor in deformity, since they are often too short and too narrow and are made of unyielding material, so that the proper action of the toes is restrained. Theoretically, the socks, like the shoes, should be rights and lefts, but if they are sufficiently large and of a texture to expand readily to the shape of the foot, but little trouble need be anticipated on this score.

CHAPTER XXII.

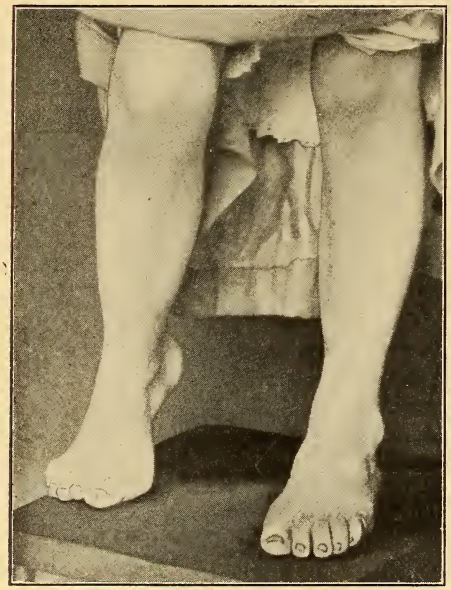
DEFORMITIES OF THE FOOT.

Talipes.

In the preceding chapters, the disabilities of the foot, of which the symptoms of pain and discomfort were of greater importance than actual deformity, have been described. One now passes to the consideration of the congenital and acquired disabilities, of which deformity is the most noticeable feature.

Distortions of the foot are, practically, fixed positions in normal attitudes, or what are exaggerations of normal attitudes; in other words the ordinary deformities can be voluntarily simulated and the centers of motion, at which the foot is deformed, are the centers of normal motion. If the foot has been fixed in the abnormal attitude during the process of formation and rapid growth, or if it has been used for any length of time in the abnormal position, the deformity becomes exaggerated beyond the possibility of imitation, and secondary variations in its shape, size and nutrition, follow.

Fig. 385.



Paralytic equinus. Recovery from paralysis, but deformity persists.

The deformities of the foot are grouped under the generic name of talipes, derived from talus (ankle) and pes (foot), signifying, therefore, a form of deformity in which the patient walks upon his ankles. Talipes was thus originally synonymous with the popular term club foot, but at the present time it is used simply as a prefix to the descriptive titles of the different distortions, while club foot is usually applied only to the most common of the congenital deformities, equino-varus, in which the distorted foot is club-like in form.

Varieties.—There are four **simple** varieties of the distorted foot or talipes :

1. TALIPES EQUINUS, the extended or plantar flexed foot. In well-marked cases the patient walks upon the heads of the metatarsal bones, an attitude that suggested the name equinus (horse-like).

2. TALIPES CALCANEUS, the dorsi-flexed foot in which the heel is prominent, and which alone bears the weight in walking; hence, calcaneus from calcaneum, the heel bone.

In these forms the center of motion is at the ankle joint. Under the terms equinus and calcaneus, are included not only the cases of marked deformity, but also those in which the range of dorsal or plan-

FIG. 386.

Congenital calcaneus. In this form the arch is obliterated. In the acquired form it is increased.

tar flexion is sufficiently limited as to cause a change in the contour of the foot.

3. TALIPES VARUS, the inverted foot. In this deformity the foot is turned in or adducted, and combined with the inward twist there is always a certain amount of supination, or inversion, that is, the inner border of the sole is elevated and the outer border is depressed, so that the weight falls to the outer side of the center of the foot.

4. TALIPES VALGUS, the everted foot. This deformity is the reverse of varus. The foot is abducted and pronated, so that, in use, the weight falls on the inner border.

In these forms of lateral deformity, the center of motion is at the medio-tarsal and sub-astragaloid joints.

These simple deformities in which the foot is persistently extended or flexed, or twisted in or out, are comparatively uncommon.

Compound Deformities.—As a rule the deformities are combined in varying degree, thus the over-extended or the over-flexed foot is usually twisted inward or outward, making four varieties of compound deformity.

1. TALIPES EQUINO-VARUS, the extended and inverted foot.
2. TALIPES EQUINO-VALGUS, the extended and everted foot.
3. TALIPES CALCANEO-VARUS, the flexed and inverted foot.
4. TALIPES CALCANEO-VALGUS, the flexed and everted foot.

In these more important deformities, the arch of the foot may be increased or diminished in depth. It is, for example, usually increased in calcaneus and equinus, and it is usually diminished in valgus; but this secondary or subordinate deformity is not recognized in the ordinary classification. If the arch of the foot is simply exaggerated, the condition is sometimes called pes cavus; if it is lessened or lost, it is called pes planus. These slight degrees of distortion, in which the functional disability is usually more important than the deformity, are rarely classed as forms of talipes. Simple cavus, the hollow or contracted foot; and pes planus, one of the forms of the common weak or flat foot, have been described elsewhere. (Chapters XXI., XXII.)

FIG. 387.

Congenital valgus.

Etiology.—From the remedial standpoint, the cause of the deformity is of far greater importance than its form. Thus one divides the distortions of the foot into two groups.

1. THE CONGENITAL FORM, in which the foot, in process of formation, has slowly grown into deformity before birth.

2. THE ACQUIRED FORM, in which the foot, perfect at birth, has at a later time become distorted.

The congenital club foot may be considered simply as a twisted foot, of which the component parts, although distorted to a greater or less degree, are capable of regaining perfect form and function. This is practically true of the great majority of cases, although there are instances in which congenital deformity is complicated by defective formation of the foot or leg, or in which the deformity is caused by, or at least accompanied by, paralysis; as for example, in certain forms of spina bifida or other defect or disease of the nervous apparatus.

The acquired deformity is nearly always a consequence of paralysis of spinal origin (anterior poliomyelitis). Certain muscles, or groups of muscles being paralyzed, usually in early childhood, the muscular

force of the foot is unbalanced and it is drawn into a distorted position by the contraction of the unopposed muscles, and by the influence of gravity. This distortion is confirmed and increased by the accommodative changes in the structure that accompany functional use and growth in the abnormal attitude.

Far less often, acquired talipes may be the result of paralysis of cerebral origin, of other forms of spinal disease; of local paralysis following neuritis or injury to a nerve trunk. It may be caused by scar contraction, as after a severe burn, or by direct injury to the bone, or by disease that may interfere with subsequent growth. (Fig. 236.) Such are, however, extremely uncommon causes, so that the statement holds good that the congenital club foot is a simple distortion capable of perfect cure. Acquired club foot on the other hand is a deformity and disability usually secondary to disease of the spinal cord; it is therefore capable only of rectification and not of perfect cure, unless recovery from the original disease, of which it is a result, has taken place.

FIG. 388.

Congenital club hands and feet, combined with anchylosis of nearly all the joints. (Compare with Fig. 389.)

Etiology of Congenital Talipes.—As of other congenital deformities, the etiology of talipes is more or less conjectural. Occasionally, the influence of inheritance is apparent, and again, two or more children with club foot may be born of the same mother, but, as a rule, nothing in the family or personal history will be found that may in any manner explain the deformity. The most reasonable explanation as applied to the majority of cases, is the mechanical. This is, in brief, the theory that the foot has from some cause remained for a longer or shorter time in a constrained or fixed position, and has thus grown into deformity.

It has been claimed by Eschricht, and also by Berg,[1] that at about the third month of intra-uterine life the thighs of the embryo are ab-

[1] Berg, Archives of Medicine, N. Y., Dec. 1, 1882.

ducted, flexed and rotated outward, the legs are crossed and the feet are plantar flexed and adducted so that the inner surfaces of the thighs, the tibial borders of the legs and the plantar surfaces of the feet, are held in close apposition to the abdomen and to the pelvis of the fœtus. Later, there is an inward rotation of the legs so that the feet are turned gradually outward until the soles are brought into contact with the uterine wall, the feet then being in the attitude of abduction and dorsal flexion. According to this theory, there is a regular succession of attitudes during intra-uterine life. If the inward rotation of the lower extremity is prevented, or if it is incomplete, the foot remaining

FIG. 389.

The etiology of congenital club hands, club foot and anchylosis of the joints. The habitual attitude at birth. Photograph at age of three months. (See Fig. 388.)

in the original position, becomes deformed. Thus equino-varus being the normal attitude of the early and middle period of intra-uterine life, is not only the most common, but it is the most intractable of the congenital deformities. But if the constraint or pressure is not exerted until a later period, after rotation has taken place, when the foot has attained or nearly attained its normal size and shape, it will then induce the rarer and comparatively slight grades of deformity, such as calcaneus or valgus.

This theory, which seems interesting and reasonable, appearsto rest on a very insecure basis. Bessel Hagen states that in embryos of 30

mm. in length, the foot is in extreme plantar flexion; in those of 90 to 100 mm., the foot is at a right angle to the leg; and from this size to that at full term, the foot may be found in any position, abducted, adducted or dorsi-flexed. He states also that supination is not the usual attitude at an early period but is more common near the termination of intra-uterine life, and when it is present it is more often combined with dorsi-flexion. In other words, there is no time when the foot regularly and normally assumes the attitude of club foot, from which it is changed by the rotation of the legs. Scudder[1] after simi-

FIG. 390.

Intra-uterine "amputations." The patient is a tailor.

lar investigations, arrived at practically the same conclusions. He states that there is no necessary relation between the age, the rotation of the legs and the position of the feet.

Although the rotation theory may not be accepted, still it would appear that there is, during the process of development, a more or less regular change in the attitudes of the limbs and feet. If they are fixed in one position during this period of rapid growth, distortion must follow; if the constraint is slight and if its influence is exerted at a late period, the deformity will be slight; if it occurs at an early period, the deformity will be more resistant.

One of the causes of constraint, and thus of ultimate deformity, appears to be the interlocking of the feet. Many museum specimens show this, and in some of the cases of talipes seen during the first week of life, the feet may be replaced in the attitude in which they had been

[1] Boston Med. and Surg. Jour., Oct. 27, 1887.

fixed before birth. (Fig. 306.) Intra-uterine pressure, although not usually the direct cause of club foot, undoubtedly has an influence in aggravating the deformity. The effect of pressure is not infrequently shown in atrophic areas of skin; and bursæ even are sometimes found over prominent bones. Entanglement in the umbilical cord, the direct pressure of intra- or extra-uterine tumors, and the like, may be mentioned also as possible causes.

Evidence of restraint and of abnormal attitudes of the limbs, is seen not infrequently in connection with club foot; for example, in hyperextension or fixed flexion of the knees, and in cases of extreme deformity, the foot is often smaller than normal, and otherwise asymmetrical. The distorted foot may be imperfect in structure; toes may be absent, "spontaneous amputation" (Fig. 390) or constricting bands about the leg or foot may be present. Such abnormalities are usually ascribed to amniotic adhesions. Talipes may be combined with evidences of impaired or arrested development; with hare lip, extrophy of the bladder, spina bifida, and absence of patellæ; or with other deformities such as club hand and wry neck. Or there may be evidence of intra-uterine disease, as in anchylosis of joints (Fig. 388) or so-called fœtal rickets. Finally, deformities of the foot may accompany or are caused by absence of bones, as of those of the foot; or other deformities and malformations, showing evidently an abnormality in the original make-up of the germ. This latter group, which includes the complications of club foot and imperfection of structure, is comparatively small, and, as has been already stated, in the great majority of cases, congenital club foot is a simple deformity capable of perfect cure.

Statistics.—The most accurate statistics are those compiled from the records of the Hospital for Ruptured and Crippled by Townsend.[1] These have been supplemented for me by the later investigations of Dr. N. B. Waller. In the combined statistics are included the data of 3,453 individual cases of talipes. Of these 1,650 were congenital, and 1,803 were acquired. The relative frequency of the congenital and acquired forms of talipes has given rise to much discussion in the past, and statistics on this point are at considerable variance with one another. This may be explained by the fact that acquired talipes is, as a rule, a preventable deformity. At the present time, the extreme degrees of acquired talipes are comparatively rare, and the deformity is usually of a much slighter grade than the corresponding form of congenital distortion.

Sex of Congenital Talipes.

	Males.	Females.	Total.
Townsend	567	348	915
Waller	498	237	735
Total	1065	585	1650
Percentage	64.5%	35.5%	

[1] A Statistical Paper on Club Foot, Trans. of the Med. Society of N. Y., 1890.

Sex of Acquired Talipes.

	Males.	Females.	Total.
Townsend	460	429	889
Waller	515	399	914
Total	975	828	1803
Percentage	54.1%	45.8%	

Congenital talipes is much more common among males than among females. All statistics are in accord upon this point. Acquired talipes is more equally divided between the sexes.

Foot Affected in Congenital Talipes.

	Right.	Left.	Both.	Total.
Townsend	274	256	385	915
Waller	236	184	325	745
Total	510	440	710	1660
Percentage	30.7%	26.5%	42.7%	
Unilateral 950, 57.2%.		Bilateral 710, 42.7%.		

Foot Affected in Acquired Talipes.

	Right.	Left.	Both.	Total.
Townsend	384	347	158	889
Waller	397	421	96	914
Total	781	768	254	1803
Pecentage	43.3%	42.6%	14.1%	
Unilateral 1,549, 85.9%.		Bilateral 254, 14.1%.		

In congenital talipes the deformity is nearly as often of both as of one foot, while in the acquired form, unilateral deformity is far more common. In each variety the right foot appears to be more often affected than the left.

The Relative Frequency of the Different Forms of Congenital Talipes.

	Townsend.	Waller.	Total.	Percentage.
Equino-varus	667	605	1272	77.0
Valgus	87	36	123	7.4
Varus	70	15	85	5.1
Calcaneo-valgus	15	37	52	3.1
Equinus	35	5	40	2.4
Calcaneus	11	17	28	1.7
Equino-valgus	14	14	28	1.7
Calcaneo-varus	4	3	7	
Cavus	1	4	5	
Valgo-cavus	1	0	1	
Equino-cavus	1	0	1	
Different deformity in each foot	9	9	18	
Total	915	745	1660	

RELATIVE FREQUENCY OF THE DIFFERENT FORMS OF ACQUIRED TALIPES TOGETHER WITH THE ETIOLOGY.

	Spinal.	Cerebral.		Other forms of paralysis.	Traumatic.	Total.	Percentage.
	Anterior poliomyelitis.	Hemiplegia.	Paraplegia.				
Equino-varus	479	28	35	4	29	575	32.5
Equinus	321	66	46	3	26	462	26.1
Calcaneus	219	3	1	0	1	224	12.6
Valgus	134	4	7	1	27	173	9.7
Equino-valgus	114	0	5	0	3	122	6.9
Calcaneo-valgus	76	0	0	0	2	78	4.4
Varus	41	2	1	0	5	49	2.7
Calcaneo-cavus	12	0	0	0	0	12	
Equino-cavus	22	0	0	0	2	24	1.3
Calcaneo-varus	11	0	0	0	0	11	
Cavus	35	1	0	0	0	36	2.0
Varo-cavus	1	1	0	0	0	2	
	1465	105	95	8	95	1768	
Deformity different on each side						50	

Anterior poliomyelitis 1465, 82.8%. Cerebral 200, 11.3%. Traumatic 95, 5.3%.

COMPARATIVE FREQUENCY OF THE DIFFERENT FORMS OF TALIPES, CONGENITAL AND ACQUIRED.

	Congenital.	Acquired.
Equino-varus	77 per cent.	32.5 per cent.
Valgus	7.4 " "	9.7 " "
Varus	5.1 " "	2.7 " "
Calcaneo-valgus	3 1 " "	4.4 " "
Equinus	2 4 " "	26.1 " "
Calcaneus	1.7 " "	12.6 " "

It will be noted that in three-fourths of the congenital cases the deformity is equino-varus, and that equinus and calcaneus, rare as congenital deformities, comprise 38 per cent. of the acquired forms.

Occasionally the deformity is different on each foot, far more often in the acquired than in the congenital form (50 of the former or 19 per cent. of the 254 acquired bilateral deformities, as compared with 18 or less than 3 per cent. of the bilateral congenital). In 7 of the 18 congenital cases, the deformity was equino-varus on one side, calcaneus on the other; in 3 equino-varus and calcaneo-valgus, and in 3 simple varus and valgus. The 50 cases of acquired talipes represented every combination of deformity.

In 31, or 4 per cent., of the 735 cases of congenital talipes in Waller's table, the distortion was combined with other congenital defects or deformities, viz.: In 12 cases with double club hands; in 6 cases with defective development of the hands, webbed fingers and the like; in 7 cases with spina bifida; in 3 cases with absence of one or more bones of the leg; in 1 case with torticollis; in 1 case with hare lip; in 1 case with dislocation of the knee and anchylosis of an elbow; in 2 cases with general rigidity and deformity of the joints.

The Anatomy of Congenital Club Foot. **Talipes Equino-varus.**—Congenital talipes is, in the great majority of cases, the form in which the foot is twisted inward and downward, so that in extreme cases it resembles the club-like extremity that has received the popular name of club foot. The ordinary congenital club foot, in early infancy, is simply a foot held in an exaggerated attitude of plantar flexion, adduction and supination. The dorsum of the foot looks forward and slightly outward and upward, the plantar surface is abnormally concave and looks backward, inward and downward. The foot often seems somewhat smaller than normal and the heel appears to be ill formed. Upon the outer dorsal surface the prominence of the astra-

FIG. 391.

Congenital talipes equino-varus (club foot).

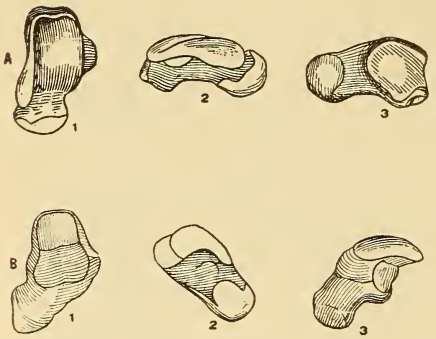
galus and os calcis may be felt beneath the skin, the external malleolus is prominent, while the internal malleolus lies deep beneath the redundant tissues of the internal aspect of the foot.

The internal structure of the foot is rearranged to correspond to the external contour; thus the relation of the bones to one another, and the shape of the individual bones even, are more or less altered as the deformity is more or less of an exaggeration of the attitudes that the normal foot is capable of assuming. These changes are most marked in the astragalus and os calcis. The astragalus is somewhat wedge-shaped from without inward; it is plantar flexed so that a large part of its body protrudes from between the malleoli. Its neck is often some-

what longer than normal, and it is, as a rule, depressed and deflected inward. (Fig. 392, B.) The os calcis is also in an attitude of plantar flexion; the internal tuberosity is drawn upward to the vicinity of the internal malleolus, its anterior extremity looks downward and inward, and it is often deflected inward corresponding to the deformity of the neck of the astragalus. Its external surface looks downward and forward, and it lies directly beneath the astragalus, instead of to its outer side, as in the normal relation.

The scaphoid bone is drawn inward and upward, and articulates with the inner part of the deflected head of the astragalus; it lies in close proximity to, and often articulates with, the internal malleolus; the cuboid is displaced upward and inward, and lies to the inner side of the anterior extremity of the os calcis. The remaining bones are changed in position, but not materially in shape. In many instances the tibia is rotated inward upon the femur, and this inward rotation of the leg may persist after the deformity of the foot has been corrected; and in other cases there is often a moderate degree of knock knee and laxity of the ligaments. Less often, the tibia is slightly twisted inward on its long axis.

FIG. 392.



The deformities of the astragalus in club foot (ADAMS). A, Astragalus of a normal infant; 1, from above; 2, from within; 3, from without. B, The astralagus in club foot in the same positions.

The ligaments are altered to correspond to the changed relations of the bones. Those on the short side are more or less resistant, according to the duration of the deformity. The muscles are normal as to their structure and their origin and insertion, but the direction of the tendons as they pass across the foot, is altered somewhat. Those attached to the inverted side, the extensor and adductor group, are shortened and are relatively stronger than those on the outer side, which are lengthened and atrophied from disuse.

To sum up: all the component parts of the foot participate in the deformity. The most noticeable changes in the bones are in their position and relation to one another, but the astragalus, os calcis, and scaphoid bones are somewhat abnormal in shape as well.

The most resistant structures in the deformed foot are the plantar fascia and the ligaments that bind the scaphoid, the os calcis and the internal malleolus to one another. The muscles that are most active in retaining and increasing the deformity are the tibialis anticus, the tibialis posticus, and the combined gastrocnemius and soleus.

The changes that have been outlined, which are comparatively slight and which may be easily rectified soon after birth, become more marked as the part develops. And when the child begins to walk, the

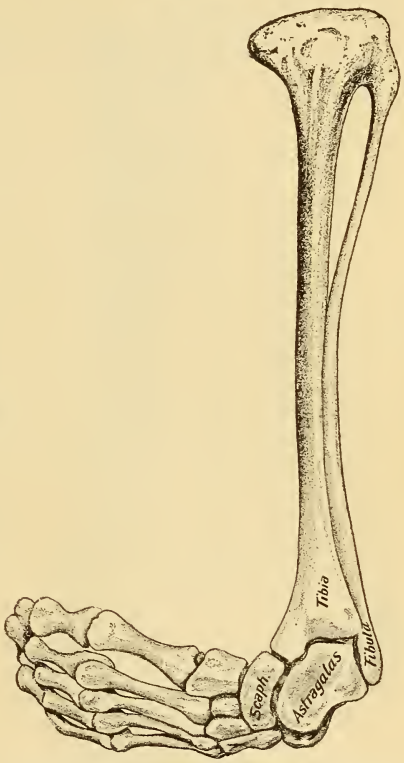
weight of the body, combined with growth and functional use in the abnormal position, increases and fixes the deformity.

In the adolescent or adult type of club foot that has remained untreated, the deformity is so extreme that the patient actually appears to walk on the outside of his ankles, as the term talipes implies. The feet turn directly inward, or even inward, upward and backward, and the peculiar walk, by which interference of inverted feet is avoided, has given another name (reel foot) to the deformity.

In such cases, knock knee is usually well marked. This, although it may be present at birth, is usually a secondary distortion caused in great part by the accommodation to the deformity, that is, by the diminution of the base of support and by the interference of the feet. (Fig. 396.)

The legs are shrunken from disuse. Over the outer border of the foot, in the neighborhood of the calcaneo-cuboid articulation, there is a large callus with an underlying bursa. The foot itself is atrophied and is much smaller than the normal. The changes in the bones are much more marked; only a small part of the articulating surface of the astragalus lies between the malleoli, and this posterior extremity is flattened out to the shape of a wedge. There is consequently backward displacement of the leg bones, which is most apparent in the position of the external malleolus. In fact, the changes in the foot may be so great as to make the component parts almost unrecognizable. (Figs. 391, 392, 393.) All the bones of the foot are more or less atrophied, and the normal area of cartilage has, to a great extent, disappeared from the proper articular surfaces.

Fig. 393.



Talipes equino-varus in adolescence, showing the displacement of the astragalus and its relation to the scaphoid, also the atrophy and distortion of the bones of the leg.

In this advanced stage, the normal muscular activity of the foot has disappeared. It is practically a simple rigid support, to which the patient has been so long accustomed that he may walk with comparative ease and with no discomfort, other than that caused by the corns and bunions at the pressure points. In these extreme cases, cure, in the sense of perfect functional recovery, is of course out of the question. But relief of the deformity, that is, replacement of the foot in the

axis of the leg, at a right angle to it and in the plantigrade attitude, is nearly always possible.

Symptoms.—The symptoms of congenital club foot have been, to all intents, included in the description of the deformity. The functional disability is of course considerable, although some patients are surprisingly active and are able to walk long distances. Discomfort from club foot is due almost entirely to the corns or inflamed bursæ

Fig. 394.

Fig. 395.

Talipes equino-varus.

The tendons on the front of the foot.

Showing the tendons in the sole of the foot and the extreme displacement of the os calcis.

over the bony prominences, and its degree depends of course upon the use to which the foot is subjected.

Treatment.—In considering the treatment of congenital club foot it is customary to divide it into several classes corresponding to the degree of resistant deformity.

The first class would include the very slight or non-resistant cases in which the deformity may be almost entirely corrected by slight manual force.

The second class comprises those cases in which a certain amount of varus and well-marked equinus remain, which it is impossible to overcome by manipulation.

The first and second classes include the forms of infantile club foot.

The third class comprises the cases of more extreme deformity, and those in which the resistance to the correction is great, as in many of the cases in early childhood, or those of later years that have been inefficiently treated.

A fourth class would include the untreated cases in the adolescent or adult.

Congenital club foot (talipes equino-varus) treated at the proper time, that is to say, in early infancy, and in a proper manner, in the great majority of cases may be perfectly cured both as to form and function.

Club foot in the adult may be made straight, but perfect functional cure is, of course, impossible.

The club foot in childhood, in which treatment has been delayed, or in which it has been ineffective, may be cured as to form or function, but the effect of the distortion remains in a certain amount of atrophy of the foot and leg, caused by the long disuse of proper function.

Although congenital club foot is an eminently curable deformity, yet perfect and permanent cure often requires minute attention to details during the active stage of treatment, supplemented by long-continued and careful supervision after the cure is supposed to be complete. No other deformity presents such a record of failures and incomplete cures, of relapses after apparent cure, of tedious and ineffective treatment by braces, often for many years, and of unnecessary and mutilating operations. Some of the failures may be explained by the neglect of the parents, or by want of opportunity. A few are due to the unusual obstacles in the deformity itself, but by far the greater number must be accounted for by failure of the physician to apprehend the true nature of the deformity, or by his inexperience in the practical details of treatment.

Principles of Treatment of Infantile Club Foot.—The infantile club foot is, as has been stated, simply a twisted foot. It is true that there are slight changes in the bones; but the bones of an infant's foot are represented by yielding cartilage, which will rapidly reform under changed conditions. The ligaments, which are accommodated to the deformity may be easily stretched, together with the more resistant muscles and their tendonous insertions, and when the proper relation of the bones to one another has been restored the joints will become normal.

The treatment of club foot may then be divided into three stages:

1. The rectification of the external deformity.

2. The support of the foot in proper position during the process of transformation of its internal structure and until the normal muscular power, unbalanced by the deformity, has been regained.

3. The period of supervision. This would include the treatment of possible complicating deformities of the knee, the laxity of ligaments and the like, as well as the over-sight of the functional use of the foot and the leg, during the early years of life.

On examining the infantile club foot one will notice the same mus-

cular activity that characterizes the normal foot. The normal infant moves the foot in various directions, in a more or less regular alternation of postures, but in the club foot, motion is in one direction only, that toward which the foot is turned. The muscles on the back and inner side of the leg, which are alone active, become relatively irritable and hypertrophied as compared with those on the front and outer side, that are disused. Thus, muscular activity of the deformed foot is in reality harmful, because it increases deformity and still further disturbs the muscular balance. For this reason the temporary restraint of motion, necessary during the rectification of the deformity, may be considered rather of advantage than otherwise. When movement is again allowed and encouraged, it must be in the directions opposed to the attitudes of deformity, with the aim of so strengthening the weakened group of muscles at the expense of the stronger, that the balance of muscular power may be reëstablished.

The First Stage of Treatment—Rectification of Deformity.—It should be stated at once, that "rectification of deformity" does not mean apparent symmetry, a misapprehension to which the majority of failures in treatment may be ascribed. It means, that when deformity is really rectified, all contracted and resistant parts must have been so elongated, that every passive motion and attitude possible for the normal foot, is equally possible and as easily attained in that which was deformed. This is actual functional rectification, as opposed to the simple straightening of deformity.

The most important part of the club foot deformity is varus. The foot that is rolled over and twisted inward to the attitude of extreme adduction (Fig. 391), must be untwisted and forced into an attitude of extreme abduction or valgus, the so-called over-correction. (Fig. 387.) Until this is accomplished no attention whatever need be paid to the residual equinus. There are two reasons for dividing the procedure into two parts: First, in order that the attention of the surgeon may be concentrated on one and the most important part of the deformity. Second, because by this preliminary untwisting, the os calcis is brought into the upright position, into its proper relation to the astragalus, to the bones of the leg and to the tendo Achillis, so that the true degree of equinus may be appreciated.

Preliminary Manipulation.—As a rule, the second or third week of life is as early as mechanical treatment can be undertaken. Until then preliminary manipulation by the nurse, more particularly manual rectification of the deformity by gently drawing the foot toward abduction and retaining it in the improved position for a few minutes, as often as is possible, may be of service in overcoming its resistance. As a treatment by itself, however, simple manual rectification is tedious and ineffective, although partial cures have been attained by perseverance in this means alone.

Mechanical Treatment.—Mechanical rectification is the treatment of choice and routine in infantile club foot. Of this treatment two methods may be described.

1. By the plaster bandage.
2. By some form of simple splint.

The principle of the two is essentially the same. The foot is drawn toward an improved position and retained there by the plaster bandage, or it may be fixed to some form of metal splint or brace whose shape is gradually changed from week to week, as the resistance lessens.

Gradual Rectification of Deformity by means of the Plaster Bandage.— In this treatment care should be taken to avoid undue pressure, irritation of the skin or insecurity of the bandage. One should place shreds of absorbent cotton between the toes; and the outer aspect of the ankle, where the skin is thrown into folds when the foot is straightened, should be smeared with vaseline. A narrow strip of adhesive plaster long enough to reach from the knee to a point an inch or more below the heel, is applied to the outer side of the leg. A thin layer of absorbent cotton is wound about the leg, just below the knee, in order to protect the skin from the hard margin of the plaster bandage, and a similar strip is carried about the toes. The foot is then drawn gently toward the abducted position, often as far as the axis of the leg, at the first dressing, without causing discomfort. While it is held in this attitude, a narrow flannel bandage is smoothly applied to the leg and foot, the band of adhesive plaster being drawn out between the folds about the ankle. A very light plaster bandage is then applied, from the knee to the extremities of the toes, and into this bandage the projecting strip of adhesive plaster is incorporated, so that no displacement of the dressing is possible. The turns of both the plaster and the flannel bandage are made from within, downward and outward, so that the tension aids in retaining the foot. When the plaster bandage, which during the hardening process has been constantly rubbed and manipulated so that it may fit the part perfectly, has become firm, a long stocking is drawn over it and is attached to the body clothing. At the end of a week the bandage is removed. The leg and foot are gently bathed with alcohol, thoroughly dried, powdered and protected as before, and the bandage is again applied. At this

FIG. 396.

Neglected club foot, showing the secondary knock knee.

second dressing, the irritable adducting muscles, after the interval of complete rest, will be much less active and the contracted tissues will be less resistant, so that the foot may be easily turned somewhat outward, or beyond the line of the leg.

After four or five applications of the bandage, at weekly intervals, the foot, in ordinary cases, can be held without resistance in the attitude of extreme equino-valgus. The sole, which at first looked backward, inward and upward will be turned in the opposite direction, forward, outward and downward, and the inner border of the foot, which was concave, is now convex. (Fig. 387.) When the varus has thus been overcorrected, treatment is directed to the secondary equinus. At this stage

Fig. 397.

The first application of the plaster bandage, showing the improved position. (Compare with Fig. 391.)

it is well to cover the bottom of the foot with a foot plate of thin wood (splint wood or cigar box cover) to give the plaster bandage more solidity, and in order that its pressure may aid in flattening the rounded sole. At first, one carries the foot upward (toward dorsal flexion) while it is still retained in the abducted position, but when the right-angled attitude has been attained, it is brought nearer to the axis of the leg. The everted position, or the attitude opposed to varus, is retained however, until correction is completed. In correcting the equinus a certain amount of force is required, sufficient to cause some discomfort during the application of the plaster, but not sufficient to cause suffering afterwards. The force is applied by means of the sole plate to the entire

foot, so that the posterior extremity of the os calcis may be drawn downward by actual lengthening of the tendo Achillis, and not, as is often the case, by an over-correction of the forefoot, while the heel remains in its original position of plantar flexion. By the proper application of force the equinus is gradually overcome; the sharp indentation or fold at the insertion of the tendo Achillis is lessened, and the heel becomes more prominent.

The reduction of the equinus may be somewhat more difficult than that of the varus, but it should be entirely corrected in three or four months from the time of beginning the treatment.

As has been stated, correction of the deformity implies over-correction. (Fig. 386.) And it is well, when this has been attained, to hold the foot for several weeks, by means of the plaster bandage, in an attitude of extreme pronation and dorsal flexion (calcaneo-valgus) in order to impress, as it were, the new position upon its structure. This concludes the first stage of the treatment, the simple rectification of deformity.

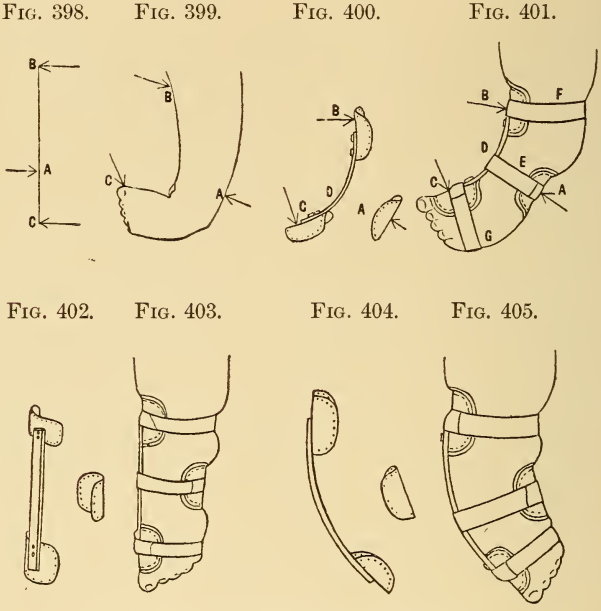
Correction by the plaster bandage has the great advantage of placing the treatment entirely under the command of the surgeon. Properly applied, the support is perfectly fitting and it holds the foot in the desired attitude without undue pressure.

The disadvantages of the treatment are almost entirely due to its improper application. For instance, the bandage may be too heavy, or the padding may be so thick that it does not retain its position. Excoriations are usually due to carelessness in the application of the bandage, or because it is not removed in proper season. The fear of compression, of atrophy of muscles, of stunting the growth of the limb, is groundless. At the end of the plaster of Paris treatment, the corrected foot is, as a rule, larger than one that has remained untreated. The stunted foot is the result of non-treatment, or of ineffective treatment by braces or otherwise; not of the enforced rest necessitated by the proper reduction of deformity.

The Rectification of Deformity by Splints and Braces.—Of mechanical supports, there are many varieties. Complicated appliances should be avoided because they are unnecessary, and because they serve to distract attention from the prime object of treatment, the rapid and systematic correction of deformity. Of the simpler braces, that used by Judson is one of the best and will serve as a type to illustrate this form of treatment. The method of application may be described in Judson's own words.

"The apparatus which I have conveniently used to effect this reduction before the child learns to stand, is a simple retentive brace which acts as a lever making pressure on the outer side of the foot and ankle, at A, in Figs. 398 to 401, inclusive, and counter-pressure at two points, one on the inner side of the leg, at B, and the other at the inner border of the foot, at C. It is advisable to keep in mind that this simple instrument is a lever, because, if we know that we are using a lever with its three well-defined points of pressure, we can make the apparatus more efficient than if we view it, in a more general way, as an apparatus for giving a better shape to the foot.

"I use a little brace made of sheet brass, doing the work with a few simple tools. An advantage of doing the work one's self is that there is no room for doubt as to where the blame lies if the apparatus does not work well. Two curved disks, B and C, Figs. 400 and 401, are riveted to a shank, D, and thus is formed that part of the brace which applies the two points of counter-pressure, while, on the other hand, the point of pressure is brought into action by a third disk, or shield, A, which is drawn tightly against the outer side of the foot and ankle, and held in place by a strip of adhesive plaster E, which includes the limb and the piece which connects the two disks, B and C. The disks are lined with two or three thicknesses of blanket, easily renewed, when necessary, with a needle and thread. These braces are so cheap



The Judson club foot splint and its application.

and easily knocked together that it is nothing to apply new and larger ones, using heavier material for the shank as the child grows. In general, three sizes will be enough, the shanks being 12 gauge, $\frac{3}{8}$ in. wide; 14 gauge, $\frac{1}{2}$ in. wide; and 16 gauge, $\frac{5}{8}$ in. wide. The disks are conveniently made from 22 gauge, $1\frac{1}{4}$ in. wide. The rivets are copper belt-rivets, No. 13. A lip turned on the edges of the disks, with the flat pliers, gives stiffness to the thin brass, and protects the skin from the rough edge. If more easily obtained, tin disks, light bars of iron or steel, and ordinary iron rivets, would doubtless answer.

"The brace is applied with three strips of adhesive plaster. The upper and lower pieces, F and G, Fig. 401, are simply to keep the apparatus in place, which they do effectively if ordinary gum plaster

is used, while, by drawing the middle strip, E, tightly over the shield, and straightening the brace from time to time, the deformity is gradually and gently reduced. At each re-application the brace is made a little straighter than the foot at that stage. This may readily be done by the hands, and then the adhesive strip is to be tightened over the shield, till the shape of the foot agrees with that of the brace. After a few days, the brace is to be made still straighter, and again re-applied, and made tight till another point of improvement is gained. The brace is applied very crooked at the beginning of treatment, as in Figs. 399 and 401, and is straightened from time to time, and a longer brace applied as the deformity is reduced and the patient grows. It should be removed every week, or two weeks, and an interval of a few days allowed for freedom from the brace, when the mother is advised to manipulate the foot constantly, using as much force as she will in the direction of symmetry. Manipulating the foot during these intervals is of great importance, as cases have occurred in which varus and equinus have been entirely overcome by the mother's hand alone."

"By this simple and prosy treatment, carried out systematically and without haste, or violence, or pain, the foot, unless it is a frightful exception, may with certainty be changed from varus to valgus. At the same time the tendo Achillis is lengthened till the position of the foot is near the normal, or at right angles with the leg, as the result of manipulation and giving the brace from time to time a partly antero-posterior action. Figs. 400 and 401 show approximately the shape of the brace at the beginning of treatment, Figs. 402 and 403 when the varus is reduced, and Figs. 404 and 405 when valgus has taken the place of varus. The foot, in this latter stage, may not hold itself valgus, when left to itself, but with almost no force and with one finger it may be pushed into valgus."

When the varus deformity is reduced, the equinus is gradually corrected by carrying the splint behind the internal malleolus, and finally, if necessary, direct upward pressure may be applied by lengthening the brace and applying it to the posterior aspect of the foot and leg. It may be noted that manipulation and stretching the contracted parts when the brace is removed, is of much importance in the correction of deformity by this or other means. Splints of wood, tin, felt and the like, may be employed, but they present no particular advantage over that which has been described.

Tenotomy.—The equinus has been spoken of as the secondary deformity, but its complete correction is often more difficult than that of varus. The mechanical stretching of the contracted parts by means of the plaster of Paris bandage, or the brace, is often accomplished with ease. But in many instances time will be gained, after the foot has been forced into the position of equino-valgus, by the division of the tendo Achillis, which is the most resistant of the shortened tissues. After division of the tendon, it is often necessary to use considerable force to stretch the other contracted parts, and to force the foot up to the limit of normal dorsal flexion, which is the object of the operation. Occa-

sionally the obstacle seems to be in the posterior ligament of the ankle, and it is sometimes of service to reinsert the knife and to divide this structure, in part at least, so that it will give way under manipulation. When the foot has been forced into the position of over-correction, it is fixed in a plaster bandage which is allowed to remain for several weeks, until the interval between the separated ends of the tendon is filled in with the new tissue.

In many instances, the leg is rotated inward upon the thigh, and the habitual attitude is accompanied by accommodative changes in the ligaments of the knee joint. During the rectification of the club foot, this secondary distortion may be, in part at least, corrected by forcible manual rotation of the lower leg outward several times daily.

Recapitulation.—The management of the first stage of the treatment of infantile club foot is then—manipulation of the foot by the nurse from birth until systematic rectification can be begun—mechanical correction, first of the varus and then of the equinus deformity, terminating with a period of retention in the over-corrected position (calcaneo-valgus). Division of tendons, other than the tendo Achillis, is not often necessary. The time required for the completion of the first stage of treatment, or over-correction of deformity, should not, under favorable conditions, exceed three months.

The rapid correction of deformity in the manner described, begun as early as possible and accomplished as quickly as possible, cannot be too strongly urged. In the first months of life the tissues are not resistant, the bones are practically entirely cartilaginous, and when the foot in its external appearance is rectified, the rapid growth in the first months of life will change the internal structure to conform to the normal conditions. The fear of atrophy, compression or other harm from the temporary fixation, necessary during rectification, is groundless, and in fact, exercise so-called, except in the direction opposed to deformity, is harmful rather than beneficial.

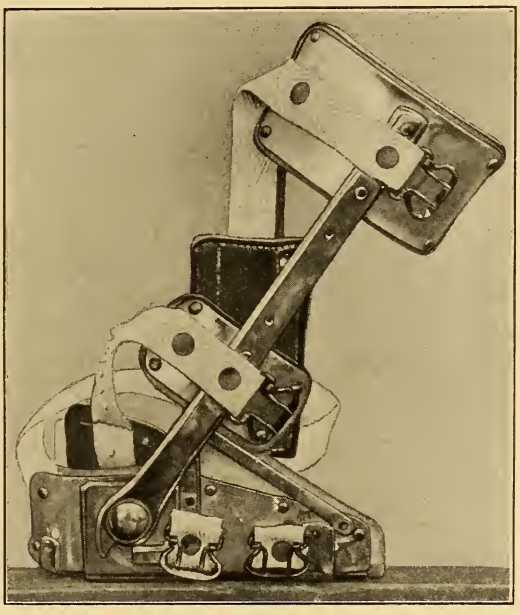
Correction of deformity may be accomplished by holding the foot in an improved position by strips of adhesive plaster, or by the elastic traction of rubber bands, attached to the leg and foot. As compared with the ease, rapidity, and certainty of correction by means of the plaster bandage, such methods are uncertain and ineffective and they will not therefore be described in detail.

The Second Stage of Treatment. Support and Restoration of Function. When the deformed foot has been corrected, in the sense that all normal motions can be carried out by passive force, the first and most difficult part of the treatment will have been completed, and, in some instances, the deformity is actually cured. Such a result is unusual however, for although the foot may be normal in appearance, its muscular balance has not been restored. This is shown by the fact that when support is removed, the foot usually hangs downward and inward, and there is little apparent power in the dorsi-flexors and abductors to draw it upward and outward. If at this stage treatment were abandoned, the deformity would almost invariably recur, at least in part.

For this reason, the foot must be supported in proper position until the slack of the lengthened tissues has been taken up by development in the normal attitude, aided by massage and stimulation of the muscles. Practically, support is always necessary until the child has begun to walk.

The Retention Brace.—The form of retention brace will vary somewhat according to the indications of the individual case. The best and simplest support is the Taylor brace, the invention of Dr. C. F. Taylor, of New York. (Fig. 406.) This consists essentially of a light upright that extends along the inner side of the leg to the knee, and a thin steel foot plate of the exact size of the sole, with an

Fig. 406.



The Taylor club foot brace.

upright flange on the inner side, rising to a point just above the dorsal surface of the foot, against which the foot is pressed closely so that recurrence of the varus deformity is prevented. The joint at the ankle is provided with a catch that prevents plantar flexion, but allows dorsi-flexion. By bending the upright and the sole plate, the foot may be held in slight abduction and eversion. The apparatus is applied with straps, as illustrated, and if necessary, its position is further fixed by a band of adhesive plaster, applied on the inner side of the leg to hold the heel firmly against the foot plate. The foot is thus held constantly at a right angle to the leg, or better in the early stage of treatment, in an attitude of dorsi-flexion and valgus. Occasionally, after complete rectification of the deformity, the

foot still turns in. In most instances, this is due to an inward rotation of the tibia on the femur at the knee joint, but in some cases, it is

FIG. 407.

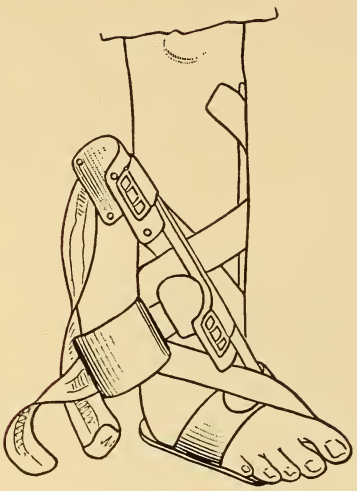
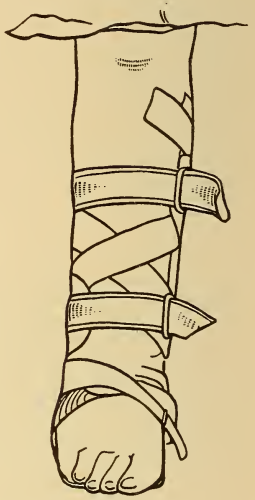


FIG. 408.



Taylor club foot brace showing the method of application and attachment.

caused by a spiral twist of the tibia itself. In order to correct this secondary deformity, an extension of the upright of the brace is carried

FIG. 409.

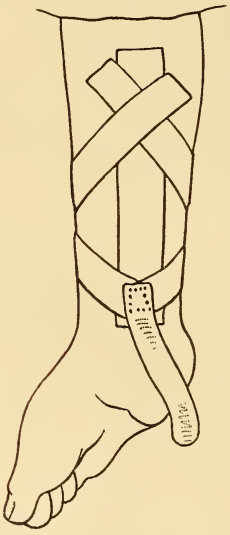
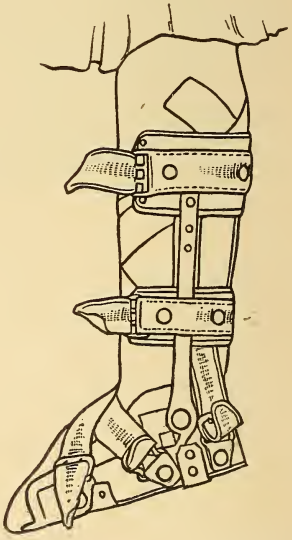


FIG. 410.



The Taylor club foot brace showing the adhesive plaster, by means of which the heel is held down, and the method of attachment. This brace may be used to correct deformity as well as to retain the foot in proper position, as is illustrated by these figures. As a retention apparatus the foot plate should be held at a right angle to the upright by the stop joint shown in Fig. 406.

beneath the leg, provided with a joint at the knee and is extended up the outer side of the thigh. At the hip it is attached by a free joint to a padded pelvic band of light steel. (Fig. 415.) The band holds the upright in the proper relation to the thigh, thus, by twisting the part below the knee, the foot can be rotated outward to the desired degree. In less marked cases the retention bands used for pigeon toe may be employed. (Fig. 377.)

Methodical Manual Correction.—Several times during the day the brace should be removed in order that the foot may be thoroughly massaged and forcibly turned, first toward valgus, that is, outward at the medio-tarsal joint so that the inner border is made convex, and then to the extreme limit of dorsi-flexion and abduction. If the leg is rotated inward, it is forcibly rotated outward on the femur. Even if the tibia is actually twisted on its long axis, the influence of the brace and forcible manipulation will usually correct the deformity. Active contraction of the weak muscles may be induced by tickling the sole of the foot or by the use of electricity; and finally, the entire limb should be thoroughly massaged before the brace is reapplied.

When the deformity shows no tendency to recur, the brace may be removed for a part of the day, later it is used only at night, and finally it may be discarded if the child walks normally. But it is best to continue the daily manipulation, more particularly the systematic stretching or over-correction of the foot, for a long time. Thus one may assure oneself that there is no tendency toward deformity, of which the first symptom is always a slight limitation of the range of dorsal flexion and of abduction.

In many instances, the deformity may have been so thoroughly over-corrected by the plaster of Paris bandage or by the brace, and the after-treatment of massage and stretching may have been so efficiently applied by the nurse or parent, that the retention brace may be unnecessary. On the other hand, the inclination toward deformity may be so marked that a brace may be necessary to hold the foot in slight abduction and valgus for a year or longer. In other cases, the use of a light brace to hold the foot in the over-corrected position during the night is alone required. These are points to be decided by the circumstances in each case. The period of observation and supervision is included in the final stage of the treatment.

Third Stage of Treatment—Supervision.—During this period, the attitudes of the limb and foot of the walking child must be carefully watched, and particularly the signs of wear on the sole of the shoe. If it shows greater wear on the outer side than is usual, it is an indication that the weight does not fall directly on the center of the foot but to the outer side, and that there is therefore a tendency toward deformity. This must be counteracted by making the sole thicker on the outer side or slightly wedge-shaped, so that the weight may be deflected toward the inner border.

This third period of treatment, or rather of over-sight of the functional use of the foot, must be continued indefinitely. In fact, it is

the quality of this final supervision that decides in most instances whether the ultimate outcome is to be what is called a satisfactory result, or a perfect cure.

The Treatment of Neglected Club Foot.

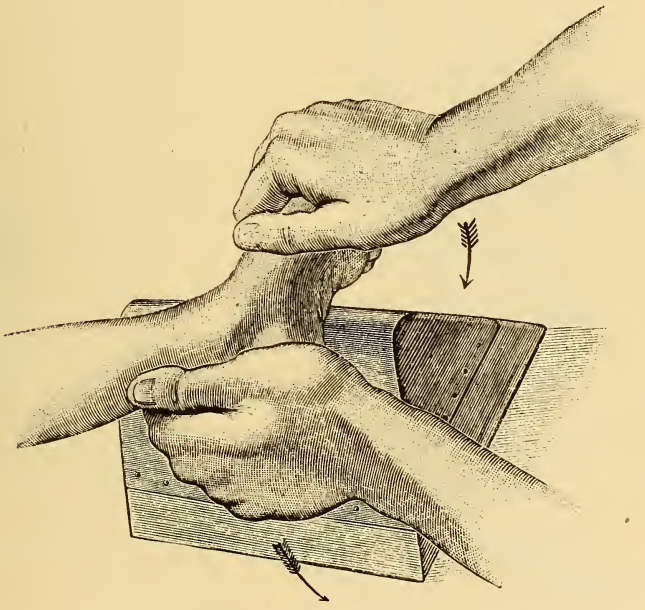
The treatment of club foot, under what may be called the proper conditions, as outlined in the preceding pages, applies practically to all cases before the completion of the first year of life, and mechanical rectification may be successfully employed in cases far beyond this limit of age. As a rule, however, when the patient has walked for any length of time, the resistance of the tissues has increased to such an extent, that more rapid and effective treatment is indicated. The investigations of Wolff have shown that the internal structure of the bones corresponds to their external contour, and that the structure and contour are adaptations to functional use. This internal structure is not, however, permanent, but is readily transformed to conform to changes in form or function. If then, the external contour of the club foot were suddenly reversed, and if use of the foot were permitted in this new attitude, a transformation of the internal structure of the bones and at the same time of their shape, would begin at once. This would continue until both structure and shape had become adapted to habitual function. It is upon this natural power of transformation that one depends for the final and complete change of the distorted bones to the normal; and what is true of a resistant structure, like bone, is equally true of the other constituents of the deformed foot.

Age as Influencing Treatment.—There is then this very essential difference between the indications for treatment in infancy and in childhood. In the first instance, the foot has no essential function. In the walking child, however, the weight of the body and habitual use tend to confirm and to increase the deformity. If walking is allowed during the process of rectification of the foot, it must necessarily retard its progress. As a general principle of treatment, walking should not be permitted, until the weight of the body may aid rather than retard the correction of deformity. The great numbers of complicated and cumbersome machines that have been used in the treatment of club foot were designed to correct gradually the deformity in walking children. But however efficacious one or another of these may have been in the hands of its inventor, or of one skilled in its use, such forms of apparatus applied under ordinary conditions, simply serve to delay effective treatment and to fix rather than to correct the deformity. The most important function of the brace, aside from its use as a correcting appliance in early infancy, is to support the foot after deformity has been corrected, and to guide it in its functional use until its normal strength has been regained. And although it may be admitted that rectification of deformity, even in adolescence, by simple mechanical means alone is perfectly possible, yet, only in exceptional

cases would one be justified in selecting a treatment so tedious, which offers practically no advantage over more rapid methods.

The Rapid Correction of Deformity.—The principles on which operative treatment is conducted are the same that govern mechanical treatment. Thus, the deformed foot must be over-corrected, and it must be held in the over-corrected position, until the immediate tendency toward deformity has been overcome. It must then be supported, until the process of transformation of its internal structure is completed, and until the balance of muscular power has been regained. This general rule of treatment is entirely opposed to the supposition that a surgical operation, no matter how radical, can be, in childhood at least, curative by itself alone. Operative procedures are undertaken simply

FIG. 411.



Reduction of the varus deformity. (LORENZ.)

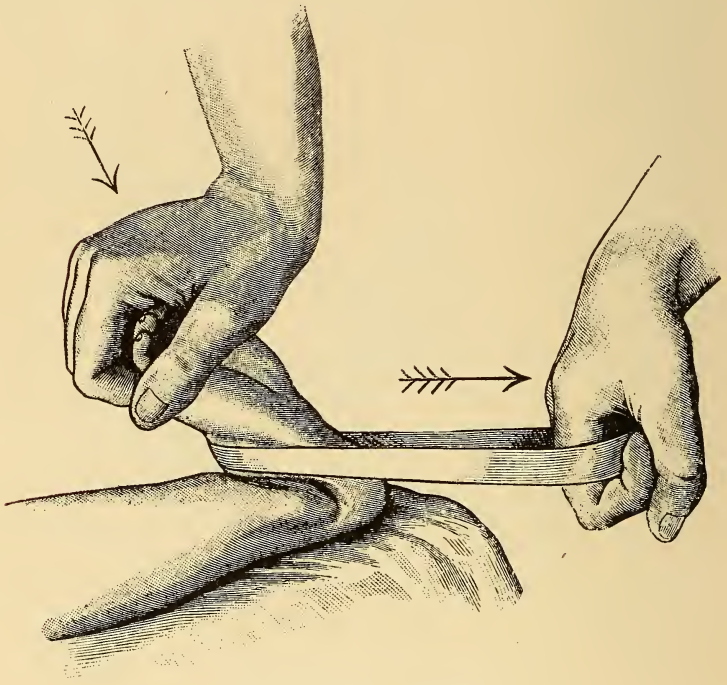
for the purpose of making the primary over-correction possible; and that operation by which this object can be accomplished, with the least interference with the structure of the foot, should be selected. Such an operation is what may be called forcible manual correction.

Forcible Manual Correction.—The patient having been anæsthetized, one first attempts to correct the sharp inward twist at the medio-tarsal joint. Supposing the left foot to be deformed, one grasps the heel with the right hand, in such a manner that the projection or muscular part of the palm lies on the outer aspect of the foot, against the most prominent part of its outer border, which is at the junction of the os calcis and cuboid bones. This hand serves as a fulcrum, over which the inverted foot may be bent. The forefoot is then grasped firmly

by the left hand and one begins a series of outward twists over the fulcrum of the opposing palm, gently at first with alternate relaxation of pressure, but with gradually increasing force as the resistant tissues stretch under the tension.

If greater force is required, a triangular block of wood, well padded, may be used as the fulcrum (Fig. 411), one hand pressing on the heel and the other on the forefoot, but there is a great advantage in using nothing but the hands, because one feels sure that no injurious force is likely to be exerted. Under this steady manipulation the foot soon loses its rigidity and its elastic recoil toward deformity—it becomes

FIG. 412.



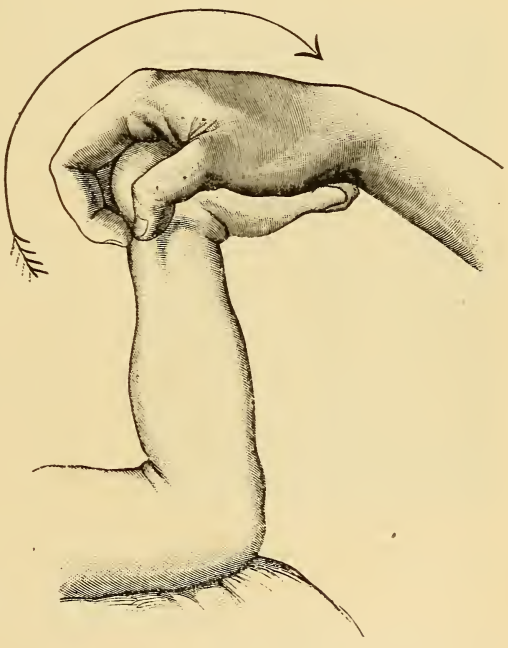
Flattening the sole. (LORENZ.)

so limp that with two fingers one can not only hold the sole straight, but can push it or bend it outwards. Thus the first stage of the methodical correction has been accomplished.

One then turns his attention to the supination which makes the outer border of the foot lower than the inner border. The leg is grasped firmly near the ankle with the left hand and with the right the foot is forcibly twisted in a direction downward, outward and upward, over and over again, with steadily increasing force as the tissues slowly yield, until it may be forced into a position of extreme abduction, so that the sole may be made to look outwards and downwards—the reverse of the former attitude.

One next stretches the contracted plantar fascia and reduces the cavus which is usually present, by forcing the forefoot toward dorsiflexion, against the resistance of the contracted tendo Achillis, until the sole is made perfectly flat. (Fig. 412.) Finally, the fourth, and often the most difficult part of the rectification, that of forcing the displaced astragalus into its proper position between the malleoli, is attempted. To accomplish this, the tendo Achillis is first divided subcutaneously, and if necessary the posterior ligament of the ankle is also divided at the same time. The patient is then turned upon his face so that with the knee resting on the table the leg is held upright. This allows one to hook the fingers about the extremity of the os calcis while the hand and arm, lying along the sole of the foot, may be used as a lever to force it toward dorsal flexion as the os calcis is drawn downward. In this manner forcible stretching is continued until the dorsum of the foot can be brought almost into apposition with the crest of the tibia. When the operation has been completed, the foot should be perfectly limp. It is usually somewhat congested from the pressure of the fingers, but it is warm and the circulation is unimpaired.

FIG. 413.



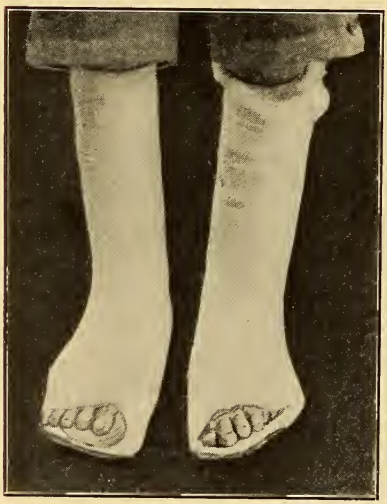
Reduction of the equinus deformity. (LORENZ.)

One may assume that in the change that has taken place from rigid deformity to a limp foot that can be moulded into the desired shape, the component parts of the deformed foot must have been subjected to considerable violence; that ligaments and muscles must have been stretched, and, it may be, ruptured; that new surfaces are now opposed to one another in the articulations, and that the bones have been forced into approximately normal position. This method of treatment has a great advantage over the ordinary operative treatment, in that the entire foot participates in the correction, instead of a limited portion, as when, for example, bone is removed by cuneiform osteotomy. It has a second and almost equally important advantage, in that the immediate use of the corrected and yielding foot is possible in the place of the necessary rest that must follow cutting operations. For these reasons forcible massage should

be the operation of choice, and preliminary, at least, to more severe procedures in the treatment of resistant club foot in childhood. The only disadvantage of the operation is the actual labor which it necessitates on the part of the surgeon, usually twenty minutes or more of rather exhausting work.

The foot must now be fixed by a plaster bandage in an over-corrected position. It is first evenly covered with a layer of cotton, and a broad bandage of canton flannel and while it is held by the assistant, the plaster bandages are applied from the tips of the toes to the upper part of the thigh. It is important that the toes should not project beyond the bandage, because of the swelling that sometimes follows. It is important, also, that the foot should be held in the proper position while the bandage is hardening, and that it should not be manipulated to any extent after the bandage is applied, in order that no rigid wrinkle may press against the skin. The bandage is applied above the knee in order that the tibia may be rotated outward to its normal position and held there, and because more effective fixation may be assured and greater pressure exerted on the foot in walking. To utilize this pressure to better advantage the bandage should be made very thick beneath the sole, and a thin foot plate of wood should be incorporated in the plaster. When the bandage is applied the position of the foot should be that of over-correction of deformity, flexed beyond the right angle, twisted far outward, and the outer border should be elevated considerably beyond the level of the inner border. (Fig. 414.)

Fig. 414.



The attitude of over-correction in which the feet are fixed after the operative treatment.

One would suppose, after using the force that has been necessarily applied, that much pain and swelling would follow. This is, however, not the case. Often, on the following day, the patients are able to stand upon the foot, and always within the first week if the bandage has been properly applied. The pain following this operation is far more often caused by pressure of an ill-fitting bandage than by the violence that has been used. Thus one should be careful to remove sections of the bandage if it appears to cause undue discomfort. These points are usually the front of the ankle, the back of the heel and the inner border of the great toe.

The Importance of Functional Use.—The immediate use of the foot is encouraged, in order that the weight of the body falling on

the yielding structure may still further correct the deformity. Although only the heel and inner border bear weight directly, yet the pressure of the foot plate on the parts that do not come in contact with the floor is usually sufficient to mould the foot into its proper shape. If greater pressure is thought to be necessary, wedges of wood or cork may be attached to the sole of the plaster bandage so that all parts may bear weight equally. The bandage is covered by a stocking; a slipper may be worn indoors and an ordinary over-shoe for street wear.

The first bandage should be removed at the end of about three weeks as it will have become loose. The foot will then be found to be extremely flexible, and by an enthusiast it might be considered cured. But knowledge of its previous condition should make it evident that a much longer time will be necessary to allow for its consolidation in the new position. At this time almost no evidence of the operation remains, except, it may be, slight discoloration of the skin. The foot is again held as far as possible in the over-corrected position and another plaster bandage is applied, usually as far as the knee only. This remains for four weeks, or longer if it is still unbroken. The patient uses the foot constantly, and is drilled in the proper method of walking, so that the muscles of the leg may become accustomed to the new and normal attitudes.

At the end of another month or more, the plaster is replaced by a brace to be worn inside the shoe, usually of the simplest description, consisting of an upright bar with a calf-band, attached to a steel sole-plate by a joint that will allow dorsal flexion but checks extension at a right angle. This is applied because the dorsal flexors, after years of disuse, only slowly recover sufficient power to resist the action of the opposing group and the force of gravity.

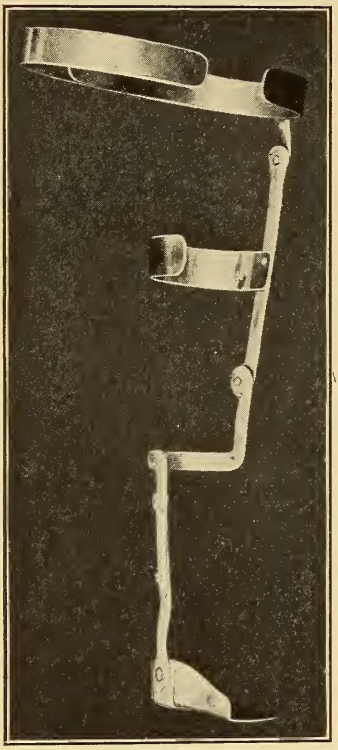
The second stage of the treatment is now begun. This may be divided into a period of active treatment and one of supervision. The first, or treatment stage, consists in massage of the entire leg and of the foot to stimulate the growth of the atrophied muscles, and methodical manipulation of the foot several times a day. The important point in this manipulation is to force the foot with the hand to the extreme of the range of motions possible immediately after the operation, viz., eversion, abduction and dorsal flexion, in the same order, as at the time of operation. At the same time the patient attempts voluntarily to carry out these motions by his own muscles, the power being supplied by the hand of the masseur. Slowly the muscles gain in strength and ability and when normal muscular power and balance have been regained the patient is practically cured. But for long afterward supervision is kept up, of the patient's attitude, of the manner of using the foot, of the wear of the sole of the shoe, and the like; and by constant drilling and stimulation the attempt is made to restore the normal appearance and function.

One cannot exaggerate the importance of this after-treatment, and of supervision at least, on the part of the surgeon. The active treatment may often be left to the parents. But constant supervision is neces-

sary to keep this after-treatment, which seems so common-place and simple, up to the proper pitch; to assure oneself that the range of motion regained by the operation does not gradually become more and more restricted, even though the contour of the foot appears to be normal.

Forcible manual correction may be employed with advantage from the second to the tenth year, although the limits may be extended in either direction in special cases. In this operation, as described, the tendo Achillis is the only structure divided. There is no particular objection to subcutaneous division of other tendons or ligaments in connection with forcible manual correction. But in such prolonged manipulation it is much better if the skin, which itself must be stretched, is unbroken and dry, rather than moist from the bleeding from punctured wounds. For this reason it is well to correct the deformity without extensive tenotomy if possible.[1]

Fig. 415.



The Taylor club foot brace with pelvic band, to prevent rotation of the leg. The brace is shown before the covering and straps are applied.

Secondary Deformities.—In cases such as have been described, a certain amount of secondary deformity of the leg is often present. Knock knee rarely requires other treatment than daily manual correction, in connection with the massage of the foot and leg. Hyper-extension at the knee will correct itself during the treatment of the foot, which being fixed in an attitude of dorsal flexion obliges the patient to bend the knee habitually in walking. Inward rotation of the leg upon the thigh is often present. This may be overcome by methodical manipulation and by the use of a brace that is attached to a pelvic band. (Fig. 415.)

In many instances, particularly in childhood and adolescence, the patient has so long walked with exaggerated outward rotation of the femur, that after correction of the deformity no inward rotation of the foot appears, even though inward rotation of the tibia be present. In other cases the inward rotation of the foot is caused by a failure to completely replace the astragalus between the

[1] Forcible manual correction appears to have been described first by Delore. Lorenz employs the method in connection with his osteoclast to the exclusion, practically, of all other treatment. (Heilung des Klumpfusses durch das modellirende Redressement, Wiener Klinik, Nov., 1895.) The modification of the treatment that has been described has been employed by the author for many years.

malleoli. Occasionally the tibia is actually twisted on its long axis, so that an osteotomy may be required in order to overcome the deformity.

Malleotomy.—In confirmed club foot, of the type under consideration, the chief obstacle to perfect correction is often the astragalus. This is displaced forward, downward and inward, only the posterior portion of its articulating surface being contained between the malleoli. Thus the space between the two bones may have become insufficient for the anterior and wider part of the body of the astragalus. In such cases, even after division of the tendo Achillis and the posterior ligament of the ankle, dorsal flexion still remains restricted and examination shows that the astragalus still projects as before, even though the foot has been forced into a position of apparent dorsi-flexion and abduction. This apparent correction is the result of over-correction at the medio-tarsal joint, of outward rotation of the tibia upon the femur and of backward displacement of the fibula.

In such instances the malleoli may be separated from one another by dividing the ligaments that hold them in apposition. A straight incision about two inches long is made directly over the anterior aspect of the articulation, the ligaments are divided and, by inserting a thin chisel, the bones are pried apart, while the astragalus is replaced in the proper position. This is usually easy if the restraining tissues on the posterior part of the ankle have been divided. The wound is then closed and the foot held in the over-corrected position by a plaster bandage. Complete correction of the varus deformity should, of course, precede this operation.

It might seem on first consideration that if immediate correction of deformity could be so easily accomplished in the confirmed cases, it should be employed even in infancy. There are, however, practical reasons against it; first, because the foot is so small that it cannot be easily manipulated, second, because even after it is corrected it must be supported until the child begins to walk, and third, because the foot can be so easily straightened without an operation, which, even of so slight a character, is sometimes cause of much anxiety to the parents. For these reasons although immediate reduction of deformity is a thoroughly practical and safe operation, it is rarely performed until a later time.

Subcutaneous Tenotomy.

The division of tendons and other tissues by the subcutaneous method, has been mentioned incidentally but as it has so long occupied an important, and even at one time the most important, place in the treatment of club foot, the operation and its effects may be described somewhat in detail.

Tenotomy, as has been stated, is performed for the purpose of removing an obstacle to the correction and over-correction of deformity. In the acquired or paralytic form of club foot, one or more shortened tendons may be the chief obstacles to reposition. But in the congenital form, in which all the tissues have grown into deformity, the shortened

tendons are oy no means the only resistant parts, and tenotomy should be considered therefore, merely as an incident in correction. In the ordinary treatment of infantile club foot, tenotomy may often be dispensed with, and in the great majority of cases division of the tendo Achillis is alone required.

When the tendon has been divided, the deformity is immediately over-corrected; thus the two extremities are separated to the extent necessary to allow the improved position. At the end of three weeks or more, or at the time when the first plaster bandage is removed, the space will be filled with new material, and in another month the splice, which will be somewhat larger and thicker than the normal, should be strong enough for use. The slight thickening at the site of the operation may be felt for a year or more, but for all intents and purposes, the new and lengthened tendon is perfectly normal, as is the function of the muscle of which it is a part.

The process of repair is somewhat as follows: Immediately after the operation the space between the divided ends of the tendon is filled or partially filled with blood; then leucocytes appear, which with those in the blood clot serve as pabulum for the plasma cells which migrate from between the fasciculi of the tendon and from the tendon sheath. The fibrin and red corpuscles of the clot are absorbed, the extremities of the divided tendon soften and become fused with the new material, which begins to take on the form and consistency of true tendon, and to separate itself from the adherent sheath. This new tendon, according to Tubby, differs from the normal structure in that the fibrous fasciculi are more irregular and its substance is more like scar tissue, but practically it is perfectly normal in its appearance and function.

Since the tendon sheath serves an important purpose in repair, it should be disturbed as little as possible. For this as well as for other obvious reasons, subcutaneous tenotomy of the tendo Achillis, which is so prominent and so distinct from other important parts is to be preferred; but if more extensive division of other tendons is required, the open operation is often indicated.

Division of the Tendo Achillis.—For this operation anæsthesis is usually required, preferably by means of nitrous oxid gas, and it is hardly necessary to state that surgical cleanliness, even in so slight a procedure, is essential.

The instrument should be small and very sharp so that no force is required in the operation; the blade should be as long as the tendon is wide. The patient is turned upon the side or to the prone position, so that the foot may be held with the heel upward by the left hand. The position and size of the tendon is ascertained by careful palpation, and the knife is then inserted to its inner side, at about the level of the extremity of the internal malleolus. The flat surface of the blade is held parallel to the tendon, and it is passed beneath it until its point can be felt beneath the skin on the opposite side. The edge is then turned upward and the tendon, being made tense, is divided by a

sawing motion of the knife. When the division is complete, as indicated by the separation of the divided ends, the knife is withdrawn, and the minute opening in the skin, from which there is usually slight bleeding, is covered with a pledget of aseptic cotton. The foot is forced into dorsal flexion and is securely fixed by a plaster bandage. In applying the dressing one should take care that no pressure is brought upon the seat of operation, as this might interfere with the effusion of plastic material. As soon as the discomfort attending the operation has subsided the patient is encouraged to stand and to walk. Functional use, far from retarding repair, is, by stimulating the circulation, an important agent in assuring firm and rapid union.

Division of the PLANTAR FASCIA is not infrequently necessary and should be performed subcutaneously. The tenotome is inserted beneath the skin at about the center of the concavity to one or the other side of the central band of the fascia, which is divided by a sawing motion of the knife. The part is put upon the stretch, and other resisting bands to the outer and inner side are divided in the same manner; the cavus is then corrected by manual or instrumental force. The operation like that upon the tendo Achillis is practically free from danger.

Division of the TIBIALIS ANTICUS is not often necessary, as this tendon offers little resistance to the rectification of deformity of the ordinary type.

The tendon of the TIBIALIS POSTICUS may be divided together with that of the tibialis anticus near the points of attachment. If the operation is required, it may be combined with simultaneous section of the CALCANEO-SCAPHOID LIGAMENT, with which are blended the anterior part of the deltoid and fibers of the anterior ligament of the ankle. ("The Astragalo-Scaphoid Capsule," Parker.) According to Parker's directions, the foot should be strongly abducted to make the parts tense. The tenotome is entered directly in front of the anterior border of the internal malleolus, its cutting edge being turned forward between the skin and the ligament. It is then turned toward the ligament, and the tissues are divided to the bone. The blade is then made to enter the interval between the astragalus and the scaphoid, and is carried downward and forward to divide the inferior part of the ligament and at the same time the tendons of tibialis anticus and posticus.

The posterior ligament of the ankle joint may be divided or sufficiently weakened, so that it may be ruptured after section of the tendo Achillis by passing the knife directly downward in the middle line upon the upper border of the astragalus.

The Correction of Confirmed Club Foot by the Method of Julius Wolff.

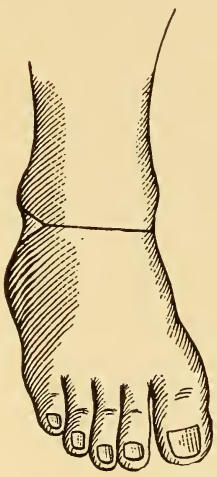
Wolff's treatment of club foot as described by Freiberg, a former assistant in his clinic, may be summarized as follows:[1] The patient is anæsthetized, and with the hands and by the use of a moderate

[1] Med. News, Oct. 29, 1892.

amount of force, the deformity is reduced as far as possible. The foot is held in the improved position by means of strips of adhesive plaster, passing from the dorsal surface of the inner border of the foot under the sole and up to the outer aspect of the leg. The leg and foot are then covered with cotton from the tuberosity of the tibia to the tips of the toes and a plaster bandage is applied. As the plaster is hardening, the position of the foot is still further improved by pressing the heel inward and the forefoot outward and upward. Two fenestra are cut in the plaster at the points of greatest pressure; one over the external surface of the ankle, and the other over the internal surface of the great toe. If tenotomy is considered necessary, it is usually performed as a preliminary operation several days before forcible correction.

On the third or fourth day after the operation, a wedge-shaped section is cut from the bandage on the outer side of the ankle joint and a linear division is made about the ankle, so that the leg and the foot parts of the bandage are separated. (Fig. 416.) The leg being held firmly, the foot is forced outward and upward to the extent that the wedge-shaped opening in the plaster will allow, and the two sections are then united by a covering of plaster bandage. For the secondary correction anæsthesia is not required. At intervals of several days larger wedges are removed and the manipulation is repeated until the patient stands with the foot in a satisfactory attitude, that is in pronation, abduction and dorsiflexion. If the deformity is extreme the bandage may be reapplied before the correction is completed with advantage. One should take care that the toes are not compressed, but lie on the same plane, in normal relation to one another. When rectification is complete the plaster bandage is covered with strips of pine shavings, held in place by a crinoline bandage, and painted with carpenter's glue. When this is hardened, the whole is covered with a thin silicate bandage; over this, the shoe is fitted and the patient is encouraged to walk. This form of dressing is used until the transformation of the deformed parts may be supposed to be complete, the time varying with the case, from a few weeks to a year. The time required for the primary correction is from a week to a month. When the bandage is finally removed, massage and exercises are to be employed.

Fig. 416.



The points at which the bandage is divided and the wedge removed. (Freiberg.)

Wolff's treatment has been thoroughly tested at the Hospital for Ruptured and Crippled. It is an efficient means of correction although somewhat tedious. It may be more conveniently employed in later childhood and adolescence than at an earlier age.

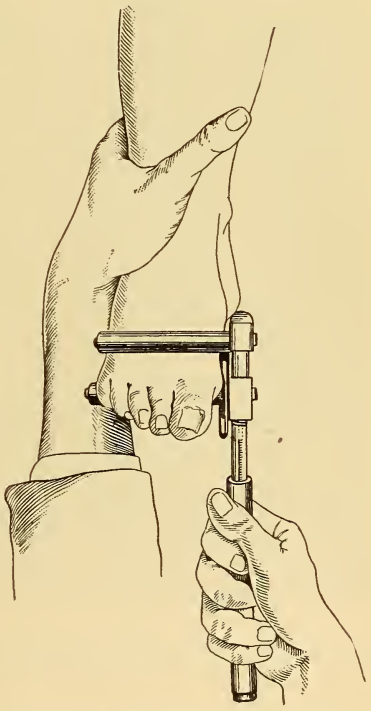
Forcible Correction of Deformity by Means of Osteoclasts and Wrenches.

In place of manual correction greater force may be employed by means of wrenches or osteoclasts to overcome the deformity. There is this important difference between the two procedures: force may be applied by the hands for as long a time as is necessary without fear of injury, while force applied by a machine must be momentary because of the pressure and strain on the parts where the leverage is exerted. Manual force continuously applied may be supposed to stretch the resistant parts, and although much less power is exerted it is really more effective than the sudden and momentary force of the wrench or osteoclast. By manual rectification the operation may be continued until the deformity has been over-corrected, while complete correction by means of instruments may necessitate several operations.

The Thomas Method.—Of instrumental correction, that by means of the Thomas wrench is one of the simplest and most efficient. The wrenching may or may not be preceded by tenotomy, a point to be decided by the resistance of the parts. As a rule division of the tendo Achillis is alone necessary. The instrument is a simple heavy monkey wrench, of which the jaws have been replaced by two strong pins slightly bulbous at the ends to keep the covers of rubber tubing from slipping off.

The wrench is applied to the inner side of the foot and screwed down so that it may "bite" and hold its place firmly, for if it slips it is likely to abrade or tear the skin; then with considerable force the foot is twisted outward and upward. (Fig. 417.) The "key note" of the operation is to so wrench the foot that it loses its elasticity, and shows no tendency to recoil toward deformity. The foot is then placed in the best possible position and is retained there by the Thomas foot splint or by a plaster bandage. In certain instances one may complete the rectification at one operation, but this not usually attempted, the procedure being repeated at intervals of a few days until the deformity has been over-corrected. In very resistant cases, eight

FIG. 417.



The Thomas wrench as used in the correction of club foot.

or ten applications of force may be necessary. When the deformity has been rectified, the foot is held in the over-corrected position for several weeks by the splint or by the plaster bandage.

As a walking appliance a simple upright of iron with a calf band is applied to the inner side of the leg, from a point just below the knee to the heel of the shoe into which it is inserted, as is the Thomas knock knee brace. (Fig. 293.) By bending the upright the foot may be kept in slight valgus, and this position is still further assured by making the outer side of the sole of the shoe thicker than the inner so that the weight falls upon the inner border of the foot. In many instances, the walking brace may be dispensed with in the after-treatment, but a light brace is usually worn to hold the foot in the corrected position during the night, until the power of the abductors and dorsal flexors has been regained. Massage and manipulation are used in the after-treatment in the manner already described.

FIG. 418.

Resistant club foot in later childhood. (See Fig. 419.)

Properly applied the treatment is satisfactory and free from danger. Sloughing of the tissues caused by the pressure of the instrument or by the plaster bandages has been reported, but such accidents have not occurred in the extensive practice of Thomas and Jones.

Correction by Means of the Osteoclast.—The late Mr. Grattan, of Cork, used the osteoclast that goes by his name (Fig. 296) to crush and to over-correct resistant club foot. The operation may include beside the correction of the deformity of the foot itself, fracture of the leg above the malleolus, to turn the foot toward valgus, and a second fracture half-way up the limb, to overcome the inward rotation or twist of the tibia. Mr. Grattan's results have been very satisfactory. Other appliances constructed on somewhat similar principles may be employed. Of these, the Lorenz osteoclast[1] and the Bradford[2] lever apparatus are the most effective.

The Open Incision Combined with Forcible Rectification of Deformity. Phelps' Operation.—When extensive division of contracted

[1] Wiener Klinik, Nov.–Dec., 1895. [2] Bradford and Lovett, 2d ed., p. 414.

parts is indicated, the open incision is to be preferred because of the opportunity thus offered for the recognition, and for intelligent selection, of structures that require division in the final correction of the deformity.

Phelps' operation is essentially simply the division of resistant parts through an incision on the inner border of the foot, combined with sufficient force, manual or instrumental, to over-correct the deformity. It is the most conservative of the more radical procedures, and by it even the most severe type of deformity in the adult can be corrected; that is to say, the deformity may be overcome and a serviceable foot may be assured to the patient. Perfect functional cure is not possible when deformity has become habitual after many years of neglect.

The steps of the Phelps operation are as follows: After proper surgical preparation the Esmarch bandage is applied. The tendo Achillis, and usually the posterior ligament of the ankle, are divided subcutaneously, and by manual or instrumental force one attempts to correct the plantar flexion. An incision is then made on the inner border of the foot, just below and in front of the internal malleolus, which is extended directly downward over the head of the astragalus to include the inner quarter of the sole. Through the incision all resistant parts are divided in order, as stated by Phelps.

1. The tibialis posticus, and the anticus, if it offers resistance.
2. The abductor pollicis.
3. The plantar fascia.
4. The flexor brevis digitorum.
5. The long flexor of the toes.
6. The deltoid ligament in all its branches.

During the successive division of the tissues, repeated attempts are made to correct the foot, and only those structures are divided that present themselves as tense and resistant tissues when the foot is forcibly abducted.

FIG. 419.

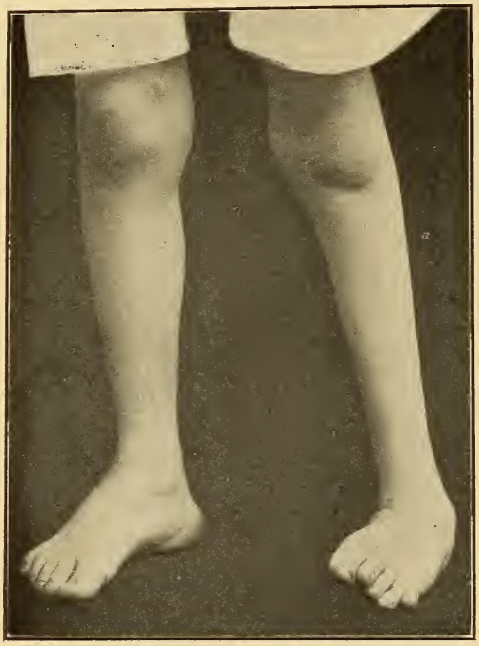
The deformity (Fig. 418) corrected by Phelps' operation and by cuneiform osteotomy of the os calcis.

In the adult type of club foot no particular effort is made to recognize the different structures, but all the tissues on the inner side of the foot including blood vessels and nerves, the deep ligaments, and occasionally the tendon of the peroneus longus muscle, are divided. Even then it is necessary to apply considerable force to correct the de-

formity. In certain instances the rectification of deformity necessitates osteotomy of the neck of the astragalus, or the removal of a cuneiform section from the os calcis. The object of the Phelps operation is, by the use of force and by division of resistant tissues, to over-correct the deformed foot at one sitting, and as much force and as extensive division of tissues as are required, should be employed by the operator.

When the foot can be held in the desired position without resistance, the wound is covered with Lister protective, the foot and leg are thickly covered with gauze and cotton, a plaster bandage is applied and the limb is elevated. The large gaping wound closes by granulation in from one to three months.

FIG. 420.



Resistant club foot in later childhood.
(See Fig. 421.)

By this operation the foot, even in severe cases in adult life, may be made straight in appearance. It is evident, however, that in such cases the correction of the deformity of the bones is by no means always perfect, for the forefoot may be simply twisted outward and upward while the astragalus and os calcis may remain in an approximation to their original deformity. After thorough over-correction by the Phelps operation the danger of recurrence of deformity in the adult and adolescent type of club foot is not great, and in many instances support other than that of the plaster bandage for several months after the operation may be unnecessary; but in childhood the ordinary precautions in after-treatment to prevent relapse will be necessary.

Malleotomy may be employed with advantage in connection with this operation. (See page 590.)

Operations on the Bones.

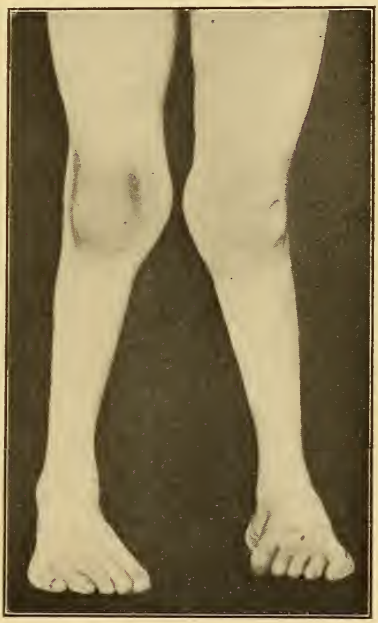
Osteotomy of the neck of the astragalus, as a supplementary part of the operation of forcible correction, has been mentioned. In certain instances, particularly in the adolescent or adult type of deformity, the displaced astragalus may offer such an obstacle to correction that its removal is indicated—an operation first performed by Mr. Lund, of Manchester.

Astragalectomy.—The astragalus is usually removed by means of an incision passing over its most prominent part, in a direction forward and downward from the tip of the external malleolus, between the tendons of the peroneus brevis and tertius. The soft parts are drawn aside, the ankle and astragalo-scaphoid joint are opened and the attachments to the scaphoid, and, as far as possible, those at the inner and outer border, are divided. The foot is then adducted so that the head of the bone may be seized with forceps and drawn upward, the interosseous ligament and the internal lateral ligament may be divided with curved scissors and the bone may be removed. If after removal of the astragalus the deformity can not be corrected, the anterior part

Fig. 421.

After forcible correction and astragalectomy. (See Fig. 420.)

Fig. 422.



Partially corrected club foot showing secondary knock knee.

of the os calcis or the external malleolus should be removed as well. A useful movable foot may be obtained by this operation, but it by no means assures the patient from recurrence of deformity. It is never indicated as a primary operation. The varus should be thoroughly corrected as a preliminary procedure; then the resistance that the astragalus offers to dorsal flexion, can be estimated. (Fig. 421.)

Cuneiform Osteotomy.—The removal of cuneiform sections of bone from the outer border of the foot is sometimes necessary, but the operation should be secondary to other methods of correction. The aim should be to lengthen contracted and shortened tissues on the inner border of the foot, to the extent required for reposition; not

to remove bone to accommodate these shortened tissues. If this has been shown to be impossible by ordinary means, then removal of bone may be indicated, but this is not often necessary in childhood or even in adolescence. If sufficient bone is removed from the adult foot to allow of perfect correction of the deformity, relapse is not usual; but in childhood, as has been stated, no operation will take the place of after-treatment.

The treatment by cuneiform osteotomy as it is ordinarily carried out is sufficiently simple. In severe cases, the astragalus is usually removed and a wedge-shaped section of bone is taken from the os calcis, cuboid, and if necessary it may include the scaphoid bone also. The external malleolus may be removed, if it interferes with reposition. Preliminary fasciotomies and tenotomies are usually performed, but those who favor this method of treatment rarely use force in reposition. In less advanced deformity the astragalus is not removed but a part of its body and neck is included in the cuneiform resection. The foot is retained in proper position until the wounds are closed; then plaster bandages are employed for several months. Braces are seldom used in the after-treatment.

Secondary Osteotomy.—In certain cases of relapsed or ineffectively treated club foot, even in childhood, deformity of the os calcis either interferes with correction of the foot or favors relapse. In such instances the removal of a cuneiform section of bone from the anterior extremity, as a supplementary part of over-correction, may be of service.

Simple Mechanical Rectification of Deformity in Walking Children and in Later Years.

It has been stated that simple mechanical rectification of deformity was possible even up to adolescence, but that the time required for such treatment, usually extending over several years, as a rule excluded it from consideration.

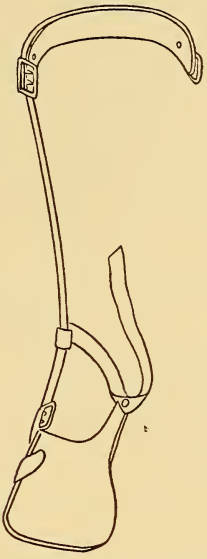
The simplest mechanical treatment is that by which the foot is slowly forced from equino-varus into equino-valgus by a brace on the lever principle, which is at first shaped to the deformity, and is then gradually straightened as the resistance diminishes. When the mid-point has been passed between varus and valgus the weight of the body aids in the correction of the remaining varus and equinus. The modification of the Taylor brace used by Judson, an advocate of pure mechanics in the treatment of club foot, will serve to illustrate the type of apparatus which, with slight change, may be employed to correct or to support the weakened or deformed foot.

The brace consists of an upright, a flat tapering bar of mild steel, a foot-plate of steel from 18 to 16 gauge, and a strong calf band. The shape of the brace, the method of its attachment to the leg by straps of webbing and its effect in gradually changing the attitude of the foot from varus to valgus are shown in the accompanying figures.

The upright is firmly riveted to the foot-plate in the angle of deformity, so that the patient must walk upon his toes; as the equinus

Fig. 423.

Fig. 424.



The Judson brace. Fig. 423 shows the construction of the brace; the foot plate with the internal flange or "riser," the upright riveted firmly to it, and the calf band. Fig. 424 shows the brace adjusted to fit the deformed foot.

Fig. 425.

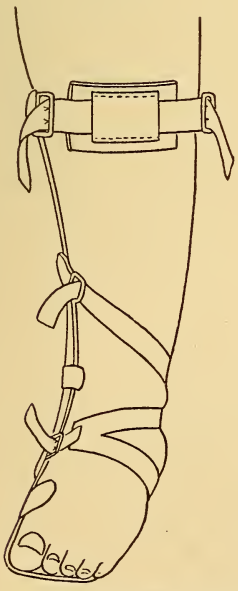


Fig. 426.

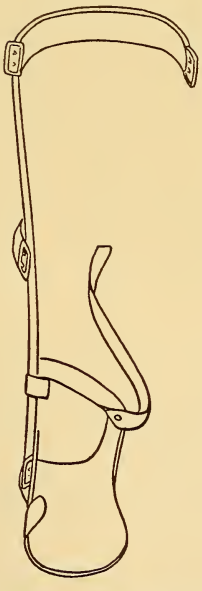
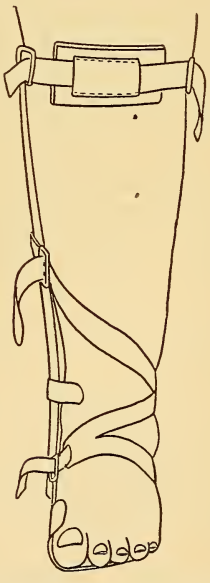


Fig. 427.



Showing the progressive reduction of deformity. Fig. 425 shows the ordinary attitude of the neglected club foot in childhood with the adjustment of the brace, it being bent to accommodate the deformity. Fig. 426 shows additional details—an upright spur useful in holding the heel, and for the attachment of straps; the spur of sheet brass that may be bent over the great toe to hold it in position. Fig. 427 shows other details in the method of attachment, a strip of adhesive plaster with two tails in the place of the band of webbing. This aids in fixing the heel. (See Figs. 428, 429.)

is decreased by the influence of the weight of the body, this angle is lessened. (Fig. 423.)

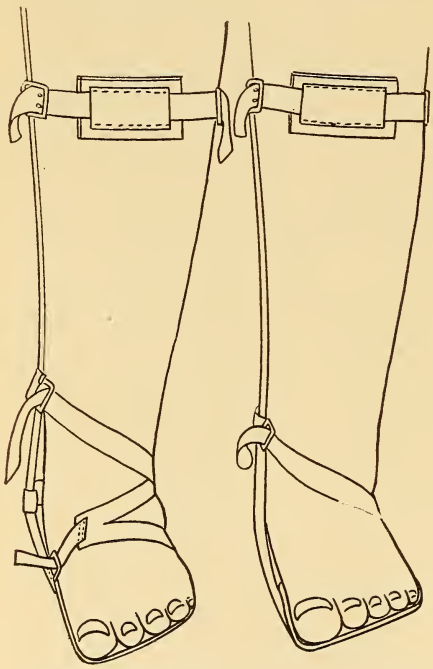
The important points are, that the brace should be strong enough to hold its place under the strain of use, and that the foot shall be firmly secured to it, whether one or many straps of webbing are required, as may be seen in the figures. The use of massage and manipulation is of course combined with the mechanical treatment.

By persistent attention to the details of treatment satisfactory results can be obtained by this method in the less resistant cases, even in adolescence.

Recapitulation of the Principles of Treatment of Congenital Talipes Equino-Varus.

The object of treatment is to overcome and to over-correct the deformity, at as early a period of life as is possible, and as quickly as possible. The object of over-correction is to overcome all the resistance of the tissues that may even in the slightest degree limit the normal range of motion in any direction. The foot must be supported in the over-corrected position until the recoil of the tissues toward deformity is no longer present.

FIG. 428. FIG. 429.



Showing the progressive reduction of deformity, and illustrating the process of changing the shape of the brace from time to time until it holds the foot in valgus. (See Fig. 425.)

It must be supported in the proper relation to the leg, and at a right angle with it, until the muscular balance has been reëstablished by stimulation of the weaker, and by limitation of the activity of the stronger, muscles, and until transformation of the internal structure has been completed.

If efficient mechanical treatment is applied at the proper time, that is to say, in earliest infancy, no operation, other than division of the tendo Achillis, will be required.

If the deformity is not corrected or is but partially corrected, when the child has begun to walk, some form of operation is as a rule indicated; but division of the resistant tissues must always be combined with the employment of sufficient force to accomplish the desired result, viz., over-correction of the deformity. Forcible manual cor-

rection, applied in the manner described, is the most efficient means of attaining this object. No instrument can equal the hand, and the force that can be applied by the hand is sufficient in all the ordinary cases in early childhood, and in combination with subcutaneous division of the more resistant tendons and ligaments, even in later childhood and adolescence.

Forcible correction by the Thomas wrench under the same conditions, is an efficient treatment, but there is a manifest disadvantage in submitting a patient to a succession of operations, even of so slight a character, if immediate over-correction can be attained by other means.

The Phelps operation, which combines thorough division of the resistant parts with the application of proper force to over-correct the foot, is the operation of selection for the more resistant cases in adolescence, in adult life, and in extremely resistant cases in childhood.

Astragalectomy and cuneiform osteotomy are never indicated as primary operations, but one or the other may be necessary for the complete rectification of the deformity when other means have failed.

Complete cure of deformity, even in the later years of childhood, is possible by means of braces alone, but such treatment is very tedious. It requires not only the continuous supervision of the skilled surgeon, but the intelligent and persistent coöperation of the parents. The results are in no way superior to those attained by more rapid methods, while the disadvantages of long-continued use of braces are sufficiently obvious. To the popular faith in braces as a cure-all of deformity, and to the unintelligent use of braces, may be ascribed now, as in former times, the failure of treatment of this eminently curable deformity. This statement seems justified, even when balanced by the equally fallacious belief, so prevalent among physicians, that a radical operation, if it does not absolutely assure a cure, is, at least, the essential part of the treatment.

Rectification of deformity, by whatever means, simply completes the first stage of treatment. Perfect cure can only be assured by attention to the small details of after-treatment, by checking the slightest impulse toward deformity, and by guiding the unbalanced foot toward perfect functional use.

Other Varieties of Congenital Talipes.

Forms of congenital distortion of the foot other than equino-varus are not uncommon, but as a rule these deformities are so slight, and, as compared to equino-varus, so easily remedied that they are relatively of little importance. This distinction does not apply however to acquired talipes which will be considered in the succeeding chapter.

Congenital Talipes Varus.

Eighty-five cases of simple varus are recorded in the table of statistics in a total of sixteen hundred and sixty congenital deformities of the foot.

This deformity often appears to be an incomplete form of equino-varus, but in some instances there is simply a slight inward twist of the foot without supination (Fig. 376); in fact, the forefoot seems to be drawn inward by the active movement of the great toe, which, in such cases, seems almost prehensile. (See pigeon toe.) In the more marked form the foot is adducted and supinated, and the tissues are very resistant.

The slight grades of deformity may be treated by simple manipulation, and if deformity remains after the first year, the shoe will, as a rule, correct it. The more marked varieties must be treated like the varus deformity of ordinary club foot, by braces or by plaster, until the varus has been transformed into valgus. The after-treatment is the same as that for ordinary club foot.

Congenital Talipes Equinus.

This is a rare congenital deformity, about half as common, according to the statistics, as varus (40 cases in 1,660). The term equinus implies that dorsal flexion is limited, but that the foot is not deviated to one or the other side (toward valgus or varus). In congenital equinus the deformity is, as a rule, slight, and in many instances it may be overcome by gentle manual force applied frequently. In the more resistant type, mechanical correction, or tenotomy, followed by over-correction and support, may be necessary.

Congenital Talipes Calcaneus.

Congenital calcaneus is comparatively rare (28 cases in 1,660). As a rule the heel is prominent, the foot is habitually dorsi-flexed, and the dorsum can be easily brought into contact with the crest of the tibia. (Fig. 386.) The exaggerated cavus, that is usually present in acquired calcaneus, is absent. Occasionally the deformity is accompanied by hyper-extension of the knee, and if, as in many instances, there is a history of breech presentation, it may be inferred that the attitude before birth was one of extreme flexion of the thighs upon the abdomen, the anterior surfaces of the extended legs being pressed closely to the ventral surface of the body, the feet being fixed in an attitude of dorsi-flexion. As a rule the deformity is slight, and the resistance of the tissues on the anterior aspect of the leg can be easily overcome by massage and manipulation. The foot should be gently forced toward plantar flexion several times in the day, and the weak muscles of the calf should be stimulated by massage.

Cure may be hastened by the use of some simple form of retention splint to hold the foot in plantar flexion until the posterior group of muscles has recovered its power. Tenotomy or other operative treatment is rarely required. In rare instances, the tibia may be bent slightly backward, thus increasing the deformity. In such cases the distortion of the bone may be overcome by manipulation and by apparatus.

Congenital Talipes Valgus.

Congenital valgus (Fig. 387) is somewhat more common than the preceding varieties (123 in 1,660). Not infrequently it is combined with a slight degree of calcaneus or equinus. The resistance of the contracted tissues is not great and the deformity may be overcome, in most cases, by persistent manipulation. If the muscular power is sufficiently unbalanced to warrant it, the foot should be held in the over-corrected position (varus) for some time.

Congenital valgus is one form of what is known as weak ankle, and it frequently passes unnoticed until the child begins to walk. If at that time, in spite of massage, the muscles appear weak or the foot inclines outward when weight is borne, it is well to make the sole of the shoe

FIG. 430.

Congenital calcaneo-valgus.

wedge shaped, the thicker part (one-quarter of an inch) on the inner side. In more persistent cases, a brace may be necessary, as described in the treatment of the acquired variety. (See the weak foot.)

Talipes equino-valgus is less common (28 in 1,660). This must be treated as the other varieties, by complete over-correction of deformity, manual or otherwise, and by subsequent massage and support if necessary.

Calcaneo-valgus (15 in 1,660), **calcaneo-varus** (7 in 1,660), **equino-cavus** (1 in 1,660), **valgo-cavus** (1 in 1,660), **cavus** (5 in 1,660), are extremely rare as indicated by the statistics. If treated early, by persistent massage supplemented by retention apparatus, these, as well as nearly all slighter grades of congenital deformity, may be corrected and cured even, before the child begins to walk.

Congenital Deformities of the Foot Associated with Defective Development.

Talipes Equino-Valgus Associated with Congenital Absence of Fibula. This is a rare deformity, but the most common of this class. The foot at birth is usually in an attitude of well-marked and resistant equino-valgus. The leg is somewhat shorter than its fellow and the tibia is often bent sharply forward, sometimes to an acute angle, at a point somewhat below the center, as if it had been broken in utero. At the most prominent point the skin may be adherent or it may present

FIG. 431.

Congenital equino-varus with deformity of the great toes.

a dimpled appearance. In some instances the formation of the foot is perfect, but more often one or more of the outer toes, with the corresponding metatarsal bones, are absent.

Statistics.—Haudek collected from the literature 97 cases; of these 46 were in males, 21 were in females and in 30 the sex was not recorded. In 67 (69 per cent.) there was total absence of the fibula. In 30 the defect was partial; of the lower extremity of the fibula in 17, of the upper extremity in 9, and of the middle in 2 cases. In 27 cases both fibulæ were absent or defective; in 68 one only, the right in 31, the left in 25, and in the others the side was not recorded. In 61 cases toes were lacking, and in these cases it may be inferred that the corresponding metatarsal bones were absent also. The fourth and fifth toes were absent in 27 cases, the little toe alone was missing in 15.

In many instances, as is usual in cases of defective development, deformity of other parts was present; for example in 17 instances the patella was absent or undeveloped, and in 11 the upper extremities were defective.[1]

Etiology.—The cause of deformity associated with absence of bone, may be either an original defect in the germ or it may be due to interference with its development. In some instances amniotic adhesions may be one of the predisposing causes; the sharp bend in the tibia, so often present, may be due to the lessened resistance of the defective part.

Treatment.—The indications for treatment are to correct the deformity of the foot in the usual manner. The bend in the tibia may be straightened by manipulation and splinting, or by osteotomy, if necessary. When the patient begins to walk the foot must be supported. A light steel upright on the outer side of the leg, provided with a T strap to hold the leg against it, will supply the place of the missing fibula. The growth of the tibia is retarded, and a final shortening of three or more inches may be expected, but with care a useful limb may be assured.

Talipes Varus or Equino-varus Associated with Congenital Absence of the Tibia.—Defective formation of the tibia is much less common than that of the fibula. Joachimsthal[2] records 31 cases. Of the 25 cases in which the sex was recorded, 17 were males and 8 females. In 23 instances the defect was of one side; in 8 both tibiæ were defective. In most cases the femur is somewhat shortened and its lower extremity is imperfectly developed. In a third of the cases the patella was absent, and in many instances other malformations were present. In nearly all the cases there was flexion contraction at the knee and the fibula was dislocated backward. The foot is practically always in an attitude of varus. The toes may be normal, but in a number of instances, the great toe was lacking. In possibly a third of the cases a portion of the tibia, usually the upper extremity, was present.

The prognosis, as regards a useful limb is extremely bad. The growth of both the thigh and the leg is much retarded, and it is almost impossible to balance the foot upon the fibula by any form of brace.

The ordinary treatment, after the correction of the deformity of the foot, has been to resect the extremities of the femur and the fibula to induce anchylosis. No final results have been reported but it may be assumed that an artificial limb would provide a more useful support than the short and distorted extremity.

Congenital Deficiency and Hypertrophy.—The leg bones may be perfectly formed, but one or more bones of the foot itself may be absent. In these cases, after the reduction of the deformity, a support to hold the defective foot in its proper relation to the leg must be used.

[1] Vide also Schwörer, Zeits. für Orth. Chir., Vol. III., p. 220. Kempke, Zeits. für Orth. Chir., Vol. III., p. 93. Cotten & Chute, Boston Med. and Surg. Jour., Nos. 8 and 9, 1898 (128 cases). Mazzitelli, Arch. Ortopedia, 1898, F. 5. Boinet, Revue d'Orthopédie, Nov., 1899.

[2] Zeits. für Orth. Chir., Vol. III., p. 140.

The foot may be divided into two parts, so that it resembles a lobster claw. Supernumerary toes, or deficiency of toes, or hypertrophy of one or more of the toes, with or without corresponding over-growth of the foot or leg, are not extremely uncommon.

These deformities must be treated on ordinary surgical principles.

Constricting Bands.

Tightly constricting bands of scar-like tissue, which cause deep indentations in the flesh of the foot or leg, are sometimes seen. These are supposed to be caused by amniotic adhesions. "Spontaneous amputations" of toes, or of the foot itself, are due to the same cause. (Fig. 390.)

In ordinary cases, the bands require no treatment, but if they interfere with the nutrition of the foot, they may be removed.

Congenital Œdema of the Feet.

In rare instances, sometimes in combination with deformity, the tissues of the feet appear to be œdematous, although the circulation seems to be perfect. The condition is apparently due to obstruction of the lymphatic circulation.

It should be treated by massage and by compression.

Spina Bifida and Talipes.

Talipes, coexisting with spina bifida, should be treated as are other forms of club foot. If paralysis of the lower extremities be present, as is often the case, the corrected feet must be supported as in the ordinary forms of paralytic deformity.[1]

[1] Über missbildungen der Menschilichen Gliedmassen und ihre entstehungsweise, Klausner, 1900.

CHAPTER XXIII.

DEFORMITIES OF THE FOOT.—*Continued.*

Acquired Talipes.

In the account of the congenital deformities of the foot it was stated that the form known as equino-varus was by far the most common, and that as compared with it, the other deformities were of slight importance.

In the acquired varieties of talipes, the equino-varus deformity is much less common, the proportion being, in the congenital form, 77 per cent. and in the acquired 32.5 per cent. of the total number. Acquired equinus comes next in frequency, 26 per cent., as compared with 2.4 per cent. of the congenital deformity, and every variety and combination of deformity finds its representative in acquired talipes, as may be seen in the tables. (See page 568.)

The Etiology of Acquired Talipes.—The cause of acquired talipes is almost always paralysis. In the table of statistics, it will be seen, that in 82.8 per cent. the paralysis was of spinal origin (anterior poliomyelitis). In 11.3 per cent. it was cerebral, the talipes being a part of the deformity of hemiplegia or paraplegia. A few cases were caused by local disease or injury of the nerves, and the remainder, or 5.4 per cent. were of traumatic origin.

The distinction between the two forms of talipes, congenital and acquired, has already been emphasized. In the congenital form the deformity is the essential disability, for when deformity has been overcome the most difficult part of the treatment has been accomplished and perfect cure may be expected. In the acquired form, the removal of deformity is but a part of the treatment, and perfect cure is not to be expected, except in that small proportion of cases in which the primary disease of the spinal cord has caused no permanent injury to its structure, or in which the deformity was the result of some slight or passing disability or disease. Again, congenital deformity cannot be anticipated or prevented. Acquired talipes is an effect of paralysis only when protective treatment has been neglected. It is a result therefore that may be foreseen and thus, by proper treatment, prevented.

Development of Deformity.—The characteristics of anterior poliomyelitis are described elsewhere. (Chapter XVII.) In its effect upon the foot the usual sequence is somewhat as follows: Immediately after its onset the paralysis is usually widespread, affecting the entire leg for example; then follows a period of partial recovery, after which the amount of damage that the spinal cord has sustained may be esti-

mated. It is during the period of partial recovery, the six months or more following the attack, that contractions, which lead to deformity, appear. If, for example, the anterior group of leg muscles is paralyzed, the foot habitually hangs downward, a position caused by the force of gravity and by the contraction of the unaffected posterior group. If this attitude is allowed to persist, the tissues accommodate themselves to the new position; the muscles which are never extended to their normal limit, become structurally shortened, while the paralyzed group becomes elongated. Even within a few weeks after the onset of the paralysis, the evidences of advancing deformity are plain. The contracted tissues resist passive motion in the directions opposed to the habitual attitude, and the child shows evidence of pain if force is used to increase the limited range of motion. As has been stated already, paralytic talipes is an unnecessary deformity. It may be prevented by supporting the paralyzed part in a right-angled relation to the limb, and by systematic passive exercise throughout the entire range of normal motions; thus improper attitudes and the secondary contractions that fix the foot in the distorted position may be avoided.

Anterior poliomyelitis is most common during the second year of life, or when the child has already begun to walk. When the first and more general effect of the disease has passed away, the child again uses the disabled limb as best it may, thus the distortion of the foot is increased and confirmed by the weight of the body and by functional use in the abnormal attitude.

The final deformity, in a particular case, can be predicted from the knowledge of the function of the muscle or muscles which has been lost. For example, paralysis of the tibialis anticus, the most powerful dorsi-flexor and adductor of the anterior group, must result in equino-valgus. If the peroneus brevis and tertius are affected varus will follow. Paralysis of the calf muscle will cause calcaneus. Paresis or paralysis of the entire anterior group will cause equinus. If all the muscles are paralyzed, what is called a dangle foot is the result; the cold atrophied member dangles from the attenuated limb with but little tendency to deformity unless it is capable of use, when it is usually forced into an attitude of equino-varus or valgus.

A slight degree of paralysis may cause so little disability that it may be entirely overlooked, and its later effect in causing disability or deformity may not attract attention for many years. This fact has been mentioned in the etiology of the contracted foot.

Differential Diagnosis Between Congenital and Acquired Deformity.—The history itself usually indicates the etiology, for deformity of the foot at birth is never overlooked by the mother. Acquired talipes is practically always preceded by a history of disease, or weakness, or injury, which was soon followed by slight, and afterward by increasing deformity.

In paralytic talipes (anterior poliomyelitis), there is evidence of paralysis in loss of function of certain muscles, as shown by electrical stimulation or by pricking the foot with a pin; later, in the atrophy

of the muscles and often in the evident change in the nutrition and diminished growth of the limb.

Only in neglected and extreme cases of talipes in the adolescent or adult, could there be difficulty in distinguishing between the acquired and the congenital deformity. In rare instances, it is true, paralysis may be present at birth, due to intra-uterine disease or to defect in the nervous apparatus. In such cases the cause of the paralysis is usually apparent (spina bifida, or spastic paralysis associated with defective cerebral development) and the treatment does not differ from that of the acquired form.

Acquired Talipes Equinus.

In well-marked equinus, the foot is plantar flexed to its full limit and it is held in this attitude by the shortened structures on the posterior aspect of the leg, of which the tendo Achillis is the most important. The patient walks upon the heads of the metatarsal bones, the toes be-

FIG. 432.

Acquired talipes equinus.

ing dorsi-flexed to accommodate the deformity. The arch of the foot is increased and the tissues of the sole, particularly the plantar fascia, are contracted. The entire foot is broadened and shortened, the breadth being especially increased across the metatarsal region. (Fig. 385.) Corresponding to the exaggerated depth of the arch, the dorsum projects, the cuneiform bones are prominent, and the head and body of the displaced astragalus may be felt beneath the skin on the anterior surface of the foot. In rare instances, and in those cases in which all the anterior muscles are paralyzed, the toes may be plantar flexed so that the patient walks upon their dorsal surface.

The cavus or increased depth of the arch is due primarily to the falling downward of the forefoot at the medio-tarsal joint, and in many instances, this dropping of the forefoot is in great degree responsible for the equinus; in fact the os calcis is rarely plantar flexed to the degree commonly found in the ordinary congenital equinus.

In the slighter degrees of the deformity when the patient still walks upon the sole of the foot, the toes are usually dorsi-flexed, an attitude due, apparently to the over-action of the extensor longus digitorum and proprius pollicis, as aids in dorsi-flexion. (Fig. 432.)

The cases of slight equinus combined with cavus have been described already under the title of the contracted foot. (Page 534.) The exaggerated arch is a secondary and a late result of the paralysis and of the equinus and in the slight degrees of deformity, particularly in the early stage of the paralysis, it may be absent.

Etiology.—Equinus in the slighter degrees is perhaps the most common of the forms of talipes acquired in later life, and it is not at all infrequent as a result of other affections than anterior poliomyelitis, although as has been stated, this is by far the most important cause. The nerve supply of the anterior muscles of the foot seems particularly susceptible, and toe-drop, from neuritis of various types, is not at all uncommon. As a sequel of infectious diseases it has been alluded to as an explanation of the slight forms of equinus first noticed after recovery from such affections.

Equinus may be a result of disease of cerebral origin, or even in rare instances, of pseudo-hypertrophic muscular paralysis or locomotor ataxia. It is sometimes the result of habitual posture, as after long confinement to the bed for the treatment of fracture or during the treatment of hip disease by apparatus; or the contraction may be an effect of voluntary posture, as when the patient habitually walks upon the toes because of a short leg. It is a very common result of neglected disease at the ankle joint, and it may be a result of direct injury, but as of paralysis, so of these less frequent causes it may be said, that equinus need never follow if the foot is properly supported.

The changes in the internal structure of the foot are similar to those that follow other forms of deformity; the tissues on the long side are lengthened and attenuated, while those on the short side become contracted. The bones themselves are but little changed in gross appearance, but the articulating surfaces are in abnormal relation to one another; for example, only the posterior part of the astragalus may be contained within the malleoli in relation to the tibia, while only the lower part of its anterior surface articulates with the scaphoid bone. In all cases of equinus there is a strong tendency toward lateral deviation to varus or valgus. This is especially true of cases of paralytic origin.

Symptoms.—The effects of the deformity vary. If the leg is actually shorter than its fellow so that the lengthening caused by the extension of the foot is no more than a sufficient compensation; and if the foot is firmly fixed in the deformed position, surprisingly little dis-

comfort or disability may be experienced, other than from corns or calluses beneath the metatarsal bones.

If the leg is not shorter, the additional length caused by the equinus must be compensated by a tilting of the pelvis and lateral deviation of the spine. This often gives rise to symptoms of discomfort in the lumbar region. The gait in this class of cases is always awkward, giving the impression as of stepping over an obstacle.

If the foot is not fixed in the attitude of equinus, that is, if it hangs downward when it is lifted, and is forced into a fairly normal attitude by the weight of the body, the gait is very awkward because of the insecurity and because of the exaggerated flexion of the knee at each step, necessary in order that the pendant foot may not drag upon the ground.

If the equinus is extreme, the limb is usually flexed at the knee when in use; if the equinus is slight the strain resulting from the limitation of dorsal flexion is felt at the knee, and in childhood at least, there is often a well-marked tendency to over-extension, or recurvatum, caused by the effort to place the sole flat on the ground.

In the slight forms of equinus, discomfort about the calf is experienced; the limitation of dorsal flexion causes a rather shortened stride and awkward gait, while an unguarded step, that throws a sudden strain upon the rigid heel cord, is felt as a shock and strain through the leg and body. Very often the patient complains of pain about the metatarsal bones (anterior metatarsalgia), and if the equinus is accompanied by a slight degree of valgus symptoms of the weak foot may be present.

The prognosis as to permanent cure depends of course upon the cause of the deformity. When it is simply the result of posture or of the ordinary form of neuritis and the like, permanent cure may be expected. In many of the cases that have followed anterior poliomyelitis, recovery, complete or partial, of the original injury to the spinal centers has followed; yet although voluntary control of the muscles has been regained it cannot be exercised because the foot is held in the distorted position by the contracted tissues. In such instances practical cure may be predicted, if after the over-correction of deformity sufficient time is allowed for the over-stretched and atrophied muscles to regain their proper length and volume.

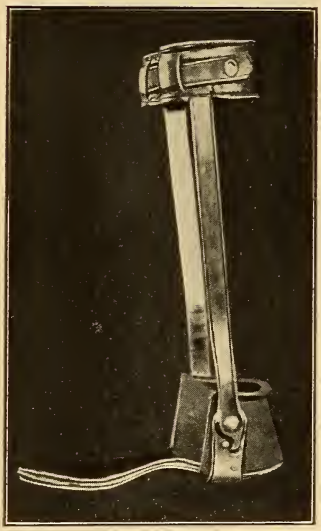
Treatment.—In the rare cases of fixed equinus combined with a short leg, in which the patient suffers no symptoms, it is well to allow the position to remain, a shoe being so built that the heel may support a part of the weight. In the more extreme cases in which the leg is short and the foot is atrophied, an extension foot attached after the manner of an artificial leg may be worn with comfort and with but little evidence of deformity.

In the ordinary cases whether permanent cure is expected or not, the rule holds good that the heel should bear the weight of the body, and that the range of dorsal flexion should not be limited when the calf muscle retains its power. If the nervous apparatus has received permanent injury, the foot must be supported after the deformity has been

rectified, but even in this class, the gait may be improved and the discomfort may be relieved by removing the restrictions to normal motion.

The slight degrees of equinus, such as those that are seen soon after the onset of anterior poliomyelitis, may be overcome by simple manipulation and retention in a splint or in a plaster bandage. In more resistant cases, in older subjects, more force may be exerted; for example, the patient being seated extends the limb; the surgeon stands in front of him, one hand holds the leg firmly at the ankle, and the other grasps the foot; the weight of the body is then thrown against the resistant tissues over and over again with as much force as is consistent with the comfort of the patient.

FIG. 433.



A brace to prevent foot-drop. One upright is often sufficient.

The Shaffer extension brace is also a useful appliance, and especially so because it may be employed to reduce the accompanying cavus at the same time.

The weight of the body as a means of overcoming equinus, when the foot is held in its proper relation to the leg by a brace, has already been mentioned, but this tedious method has but little to recommend it in ordinary cases. The elastic tension of straps and bands attached to a brace or to the foot itself by means of adhesive plaster is of some service in slight cases, but by far the most effective method is the immediate reduction of the deformity, by simple forcible manipulation under anæsthesia, or by tenotomy combined with forcible manipulation, or by wrenching.

Immediate Correction of Deformity.—Attention has been called to the cavus as an important element in equinus, and whenever one attempts to correct the equinus deformity by force, the exaggerated arch should be reduced to its normal depth, otherwise the foot will appear stunted and deformed.

One of the most effective procedures is forcible reduction by means of the Thomas wrench. (Fig. 417.) The resistant bands of the plantar fascia are first divided subcutaneously, the wrench is then fixed to the foot and with sudden force, exerted against the resistant tendo Achillis, the foot may be straightened, the deep ligaments being ruptured or stretched to the proper degree. The tendo Achillis is then divided, a wooden foot plate is placed against the sole, and the foot, having been dorsi-flexed, is fixed by a plaster of Paris bandage.

As the patient is encouraged to walk upon the foot as soon as possible, the weight of the body forcing the relaxed tissues against the unyielding board incorporated in the plaster completes the flattening of the arch. In many of these cases, the knee has been over-extended by

use in the deformed attitude, so that the habitual flexion necessary to bring the dorsi-flexed foot upon the ground, during the two months allowed for the complete union of the divided tendon, is of benefit, as it serves to correct this secondary weakness and deformity.

THE TONIC EFFECT OF IMMEDIATE CORRECTION.—The importance of the tonic effect of immediate relief of the strain of the deformed position upon the weak anterior group of muscles, together with the complete relaxation of the over-stretched tissues, during the long rest in the over-corrected position, is not generally appreciated. Whenever the weakened muscles, after paralysis, show by tests electrical or otherwise, that they have recovered their power in part, this

FIG. 434.

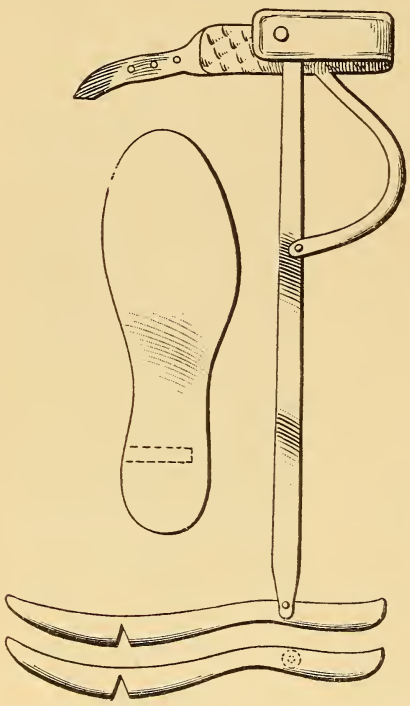
An effective and inconspicuous support for paralytic toe-drop. An upright of light tempered steel, carefully adjusted to the inner side of the leg and ankle provided with a light calf band. This is strengthened by a posterior support attached to the upright. The lower end of the brace is arranged as a caliper and is fitted to the metal disc of which two views are shown. A depression is cut in the heel of the shoe for the disc as is shown in the diagram. Two strong elastic tapes are sewed to the leather of the shoe. These are attached to the studs on the front of the calf band and thus the toe-drop is prevented. (See Fig. 435.)

treatment should be that of selection. The application of electricity or other form of stimulation to muscles that are unable to exercise their function because of contraction of the opposing tissues is absolutely useless. Nor is any form of artificial stimulation equal to that of the functional use, which is made possible by the removal of the deformity and by the employment of proper support.

Equinus, more often than any other deformity, is the result of slight or temporary disability of the anterior group of muscles, and not infre-

quently perfect cure seems to have been attained when the plaster bandage is finally removed, usually at the end of two months or more. But even in such cases, the application of a simple support to hold the foot at a right angle with the leg for several months, is of advantage. The after-treatment by massage, muscle-beating, electricity, and the like, combined with methodical passive movements to the limit of dorsal flexion, to guard against recontraction of the calf muscle, should be continued for a long time, or until the muscular balance has been regained.

Fig. 435.



The same appliance (Fig. 434) provided with a foot plate of metal or of wood as shown in the diagram. This modification is useful if the paralysis is complete or if the foot is much atrophied.

The same form of support is necessary in cases of hopeless paralysis, to hold the foot at a right angle with the leg. The common form is a simple steel sole plate of sufficient size to support the foot and the toes, if their muscles are paralyzed, attached to a light upright, provided with a calf-band. The upright is usually applied on the inner side of the leg, where it is least noticeable. At the ankle, there is a "stop joint," which allows dorsi-flexion but prevents the toe-drop. This, when properly fitted, can be placed inside the ordinary shoe, as the paralyzed foot is usually somewhat smaller than its fellow. (Fig. 433.) If the toes do not need support, the upright can be attached to the outside of the shoe and the foot plate may be dispensed with. Or, the upright may be concealed by introducing it inside the shoe to a joint sunk in the heel; the toe-drop being prevented by straps passing from the front of the upper leather of the shoe, to the calf-band. (Fig. 434.)

Equinus, due to posture or to disease, may be cured by simple correction of the deformity. That due to fracture, when the deformity is caused by displacement of the bones, may be treated by direct operation or by the removal of a cuneiform section from the anterior surface of the tibia above the ankle. (See tendon grafting and arthrodesis.)

Acquired Talipes Calcaneus.

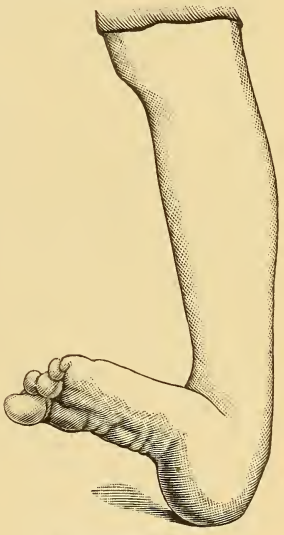
Acquired talipes calcaneus is much less frequent than equinus and it is practically always of paralytic origin (anterior poliomyelitis), although

cases of calcaneus following injury or disease or distortion of the limb are occasionally seen.

There are several varieties or grades of the deformity. In the early stage, and especially if all the muscles of the posterior group have been paralyzed, the foot assumes an attitude of slight dorsi-flexion and the range of plantar flexion is gradually lessened by secondary contractions. This variety resembles closely the congenital form. (Fig. 386.) In the ordinary and typical form of calcaneus, when fully developed, the patient walks, as the name implies, on an elongated heel. The arch of the foot is much increased in depth, and the forefoot is atrophied and useless.

DEVELOPMENT OF DEFORMITY.—The development of the deformity is somewhat as follows: When the tension of the calf muscle is removed the os calcis gradually assumes an attitude of extreme dorsi-flexion. It stands on end so that its posterior surface becomes inferior. The posterior projection of the heel is lost and it lies in the plane of the atrophied calf. The change in the position of the os calcis increases the distance from the malleoli to the ground, thus calcaneus though in less degree than equinus, makes the leg longer. The turning of the heel on end, thus lengthening one of the terminations of the arch, increases its depth and at the same time shortens the length of the foot so that cavus, in more marked degree than with equinus, accompanies calcaneus. The cavus is a later complication of nearly all cases of paralytic calcaneus. In many instances there is no permanent dorsi-flexion or elevation of the forefoot, although in all, the range of plantar flexion is limited. In this class the power in the remaining muscles of the posterior group is probably sufficient to counteract the contraction of the dorsi-flexors. Cavus is thus a direct effect of the displacement of the os calcis. If the entire posterior group of muscles is paralyzed, while the anterior muscles are unaffected, the foot will be somewhat dorsi-flexed and the cavus will be less marked. If the calf muscle only (gastrocnemius and soleus) is paralyzed, the remaining muscles of the posterior group will counterbalance the dorsi-flexors, and at the same time increase the cavus. In some instances the calf muscle is alone affected, in others one or more of the anterior muscles may be paralyzed also, in which case the foot is usually turned toward varus or valgus. The changes primarily caused by the paralysis and by unopposed muscular action become fixed by habitual use, and by secondary adaptation of the tissues. The heel only, is used in walking, and the area of callus which marks the weight-bearing surface becomes much enlarged, while the

FIG. 436.



Paralytic calcaneo-varus.

forefoot and toes which have but little functional use become atrophied, a mere appendage to the enlarged heel. (Fig. 439.)

Symptoms.—The gait is awkward and inelastic, the patient, who is as it were "ham-strung," stamps along upon the insecure support of the heel in a manner which is easily recognizable by one familiar with the deformity. The changes in the internal structure of the foot, the inevitable adaptations to the deformity do not call for especial description, the disused bones atrophy together with the other tissues, and new articulating surfaces form to accommodate the necessities of functional use.

Treatment.—The essence of successful treatment is prevention. When the diagnosis of paralysis of the calf muscle is made, one may predict, unless recovery takes place, a deformity such as has been described. This deformity may be prevented by proper support, by

FIG. 437.

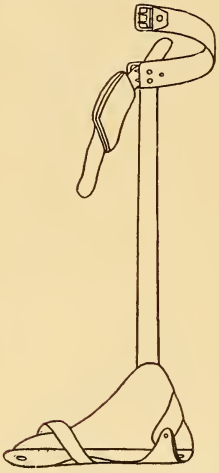
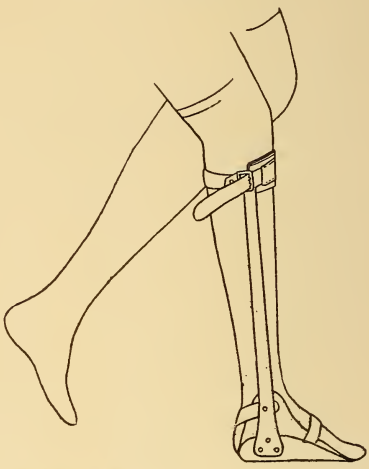


FIG. 438.



Judson's brace for calcaneous deformity.

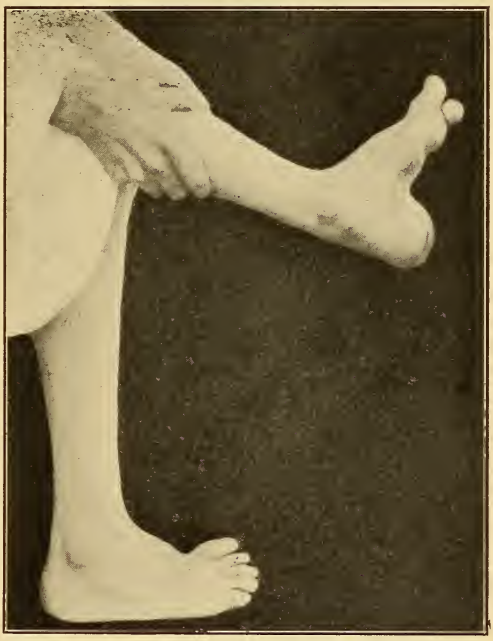
massage and methodical stretching of the tissues that have a tendency to contract. The form of brace used for walking and support, should be provided with a sole plate, upright and calf-band, as already described in the treatment of paralytic equinus. If motion is allowed at the ankle it should be in plantar flexion only, the stop being the reverse of that used in equinus, or as this form of check entails much strain upon the brace, the joint may be omitted as in that form used by Judson. (Figs. 437, 438.) Thus the strain, removed from the weakened tissues, is borne by the anterior surface of the leg. Other forms of braces are sometimes employed, provided with elastic bands to supply the place of the calf muscle, but as a rule the improvement in gait hardly compensates for the trouble in adjustment or the conspicuousness of the appliance.

The most important part of the actual deformity of calcaneus is the

cavus, in great part due to the changed position of the os calcis; and in confirmed cases it is practically impossible to reduce this except in part, because the loss of resistance of the tendo Achillis takes away the point of fixation, against which effective force can be exerted. If the deformity is not marked, the foot may be drawn as far as possible toward equinus and fixed in a plaster bandage, the sole part being strengthened by the insertion of a thin board. Upon this the patient may walk, the heel being built up with cork wedges to make the sole level. When the contraction of the anterior tissues has been overcome, the brace is applied and the usual treatment of manipulation and massage is continued.

The method of prolonged fixation in the attitude of equinus by means of the plaster bandage is often very efficacious in childhood and cures of apparently hopeless cases by this means have been reported.[1]

Fig. 439.



Paralytic calcaneus, showing secondary changes in contour.

Operative Treatment.—In more extreme cases immediate reduction of the deformity under anæsthesia may be attempted. The plantar tissues, more particularly the plantar fascia, may be divided subcutaneously or by open incision and by forcible manipulation or wrenching the sole may be somewhat lengthened and the heel pushed somewhat upward and backward, so that the foot may be fixed in a plaster bandage in slight plantar flexion. In the reduction of the deformity one must not force the forefoot downward as this would simply increase the cavus, but whatever correction is accomplished should be by means of elevation of the os calcis and elongation of the tissues of the sole of the foot.

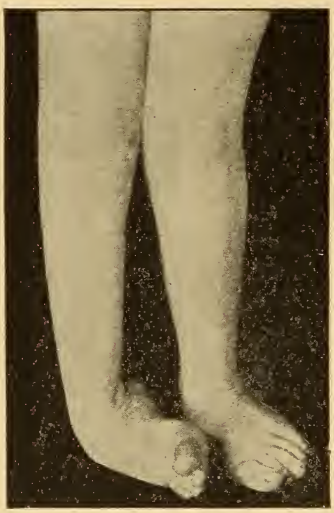
In some instances the improved position of the os calcis may be confirmed by shortening the tendo Achillis, as first performed by Willett, of London.[2]

Willett's Operation for Calcaneus.—A Y-shaped incision about two inches in length is made through the tissues down to the tendon. At

[1] Gibney, Trans. Am. Orth. Ass'n, Vol. XIII., 1900.
[2] St. Bart's Hosp. Reports, Vol. XVI., 1880, p. 309.

the lower or vertical part of the incision, which is continued down to the tuberosity of the os calcis, the tendon is dissected free from the surrounding parts. It is then divided in an oblique direction from within outwards, and downwards, and the heel having been pushed upward as far as possible, the divided ends are overlapped and sutured; the flap of skin is drawn downwards at the same time, so that the Y-incision is converted into the shape of a V. According to Mr. Willett's original directions, deep sutures are passed through the skin flaps and through the tendon on either side, so that all the tissues are united. The foot is then fixed in a plaster bandage, and the patient is allowed to walk about wearing a high heel to compensate for the elevation of the sole.

FIG. 440.



Paralytic varus and valgus. (GIBNEY.)

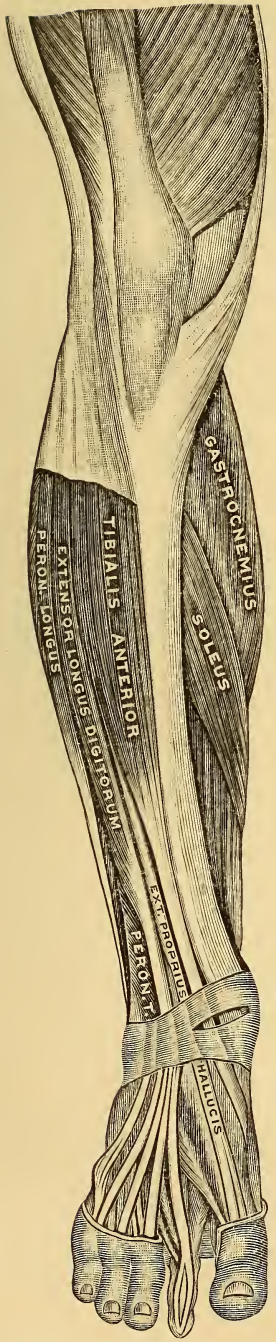
The operation is of value in those cases in which some power remains in the calf muscle, which is thus made serviceable.

In cases of complete paralysis the position of the foot may be temporarily improved, but unless proper support is used afterward the tissues will stretch under the strain of use; thus the treatment should always be supplemented by a brace of the character already described. (Fig. 438.)

Astragalectomy and Backward Displacement of the Foot.—In cases of confirmed calcaneus or calcaneus combined with lateral deformity, varus or valgus, removal of the astragalus may be indicated. This operation permits the malleoli to be brought into direct contact with the os calcis, thus increasing the security of the foot.

The astragalus may be removed by a long, curved, external incision passing from the tendo Achillis just below the outer malleolus to the front of the joint. The peronei tendons are divided, the foot is displaced inward and the astragalus is removed. The articulating surfaces of the leg bones and of the os calcis, are denuded of cartilage; the tendo Achillis is shortened and to it the peronei tendons are attached if the muscles are active. The entire foot is then displaced backward so that the denuded malleoli overlap the anterior extremity of the os calcis. The object of this procedure is to throw the weight of the body upon the center of the tarsus; thus the deformity is reduced and the stability of the foot is increased. The wound is closed and the foot is fixed in plaster of Paris. As soon as possible the patient uses the foot in standing and walking. Ultimately apparatus may be dispensed with, but the Judson brace may be used for a time with advantage. This operation has been performed in many instances by

Fig. 441.



The muscles and tendons on the front of the leg. (Testut.) From Gerrish's Anatomy.

Fig. 442.

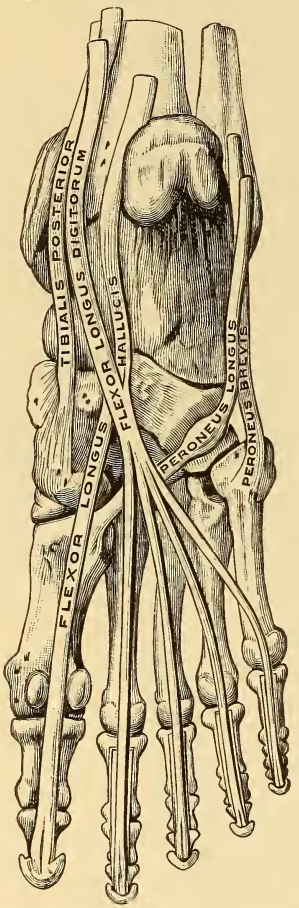
The muscles and tendons on the back of the leg. (Testut.) From Gerrish's Anatomy.

the author, for whom it is now the treatment of choice in this type of deformity. (Fig. 438.) By it the usefulness of the foot is greatly increased and its appearance very much improved.

Acquired Calcaneo-Valgus and Calcaneo-Varus.

In many cases, the foot deformed as a result of paralysis of the calf muscle is in addition turned in a lateral direction, so that the weight of the body falls to the inner or outer side of its center. (Fig. 436.)

Fig. 443.



Tendons in the right sole. (Testut.) From Gerrish's Anatomy.

Calcaneo-valgus in which the foot is turned outward and upward so that the patient walks on the inner side of the heel or even on the inner ankle is not uncommon. It is usually a result of more extensive paralysis than simple calcaneus. For example, all the muscles about the foot may be disabled except the peronei, or in cases of a milder type the tibialis anticus may be the only muscle of the front of the foot that is paralyzed.

Treatment.—When the foot inclines toward calcaneo-valgus it is difficult to hold it in proper position. The usual method is to apply the brace, used for ordinary calcaneus, with the upright on the outer side of the foot; the ankle and arch are then held against it by means of a leather strap. Another form of brace is provided with an upright on either side of the leg, the outer being slightly longer than the inner so that the sole plate is tilted inward, or as it were supinated; thus the weight is guided towards and balanced on the outer side of the foot. It must be borne in mind that other muscles of the limb are often paralyzed, so that the deformity of the foot may be but a part of more general distortion, so that the foot brace is often combined with apparatus for the support of the leg. (Fig. 314.)

In the more extreme cases the deformity may be reduced, and the stability of the foot may be increased by the removal of the astragalus in the manner described.

Calcaneo-varus is a much less serious affection, since the foot may be more easily supported. A brace, such as is used in the treatment of ordinary varus, without motion at the ankle, or provided with a reverse stop, is ordinarily employed.

Acquired Talipes Equino-varus.

Talipes equino-varus is, in the acquired as in the congenital form, the most common of the deformities of the foot. (Fig. 440.)

The tendency of simple equinus is usually toward varus, because in plantar flexion the foot is slightly adducted, and because the outer side of the foot is shorter than the inner side so that in walking with the foot extended the tendency of the foot is to turn somewhat inward. Equino-varus is usually preceded by equinus, and the etiology of the one will serve for the other. (Page 612.)

In certain cases the varus is more marked than the equinus, as for example when the abductors of the foot are paralyzed while the adductors retain their power; or in cases of direct injury as in fracture at the ankle; or when the growth of the tibia has been arrested as the result of injury or disease.

A detailed account of the appearance and effect of the deformity is unnecessary. In the early stage of the paralysis it may be reduced easily; the foot must then be supported by a brace, of which the Taylor club foot apparatus is the type. (Fig. 410.) During the night the over-corrected attitude may be assured by a strap running from the upright to the sole plate.

If the deformity is fixed it should be reduced and over-corrected by forcible manipulation under anæsthesia. Division of resistant parts is less often necessary than in the congenital form, but it may be required in neglected cases. The over-corrected position should be retained until time has been allowed for the recontraction of the lengthened tissues; for as has been mentioned in the treatment of equinus, over-correction and rest is by far the most effective treatment that can be applied to a weak or paralyzed part. A support is then used of the character indicated.

Astragalectomy and cuneiform osteotomy are rarely indicated, but the latter operation is sometimes of service in checking the tendency toward recurrence of deformity, which is more marked after over-correction in the paralytic than in the congenital talipes.

Acquired talipes equino-valgus is much less frequent than the preceding deformity. Simple equino-valgus is usually the result of primary paralysis of the tibialis anticus, the most powerful of the dorsal flexors; thus the foot is drawn somewhat outward when dorsi-flexed, while the metatarsal bone of the great toe, having lost the support of the tibialis anticus muscle, falls downward and is drawn outward by the peroneus longus. In this type one's attention is often attracted by the peculiar appearance of the great toe, which is deformed somewhat like a hammer toe by the over-action of the extensor longus pollicis, in its attempt to take the place of the tibialis anticus. The equinus is usually slight and is secondary to the valgus. Treatment may be begun by placing the foot in a plaster bandage in an attitude of varus and allowing the patient to walk upon it until the tendency toward deformity has been overcome. A support with the catch, as for toe-drop, is applied to the

shoe, and the tendency toward valgus is checked by raising the inner border of the sole or by the use of a sole plate, as in the treatment of the simple weak foot. (Fig. 440.)

Acquired simple talipes valgus, from paralysis of the tibialis anticus and posticus is rare. Talipes valgus, as when the foot is dislocated outward, in cases of complete paralysis of all its muscles, may be considered as a variety of dangle foot.

Traumatic valgus and equino-valgus, caused by fracture at the ankle (Pott's fracture) may be treated by osteotomy of the tibia above the ankle. By this means the proper relation of the leg to the foot may be restored in many instances. Equino-valgus of slight degree is not uncommon after tuberculous or rheumatic disease at the ankle or at the astragalo-scaphoid joints. This is practically one variety of the weak foot.

Talipes valgus, sometimes called spurious valgus, the simple weak or flat foot, has been described elsewhere (Chapter XX.).

Talipes caused by cerebral disease, whether of the paraplegic or the hemiplegic type, is almost always of the form of equino-varus in early childhood. In adolescence the deformity may be equino-valgus or even calcaneo-valgus if there is extreme flexion at the knee. The hemiplegic form of talipes is much more rigid and unyielding than the paraplegic type. The treatment of spastic paralysis, of which the deformity is a part, is discussed elsewhere (Chapter XVIII.). The deformity must be corrected by the ordinary methods. In many instances, when the contractions are not marked, mechanical treatment is unnecessary.

Hysterical equino-varus, or other form of deformity, is not especially rare. The diagnosis may be made from the other symptoms of hysteria, from the history of the onset and duration of the distortion, and from the appearance of the deformity, which is evidently merely an assumed posture. (See page 471.)

Tendon Transplantation for the Relief of Paralytic Talipes.

When one or more of the muscles are paralyzed the unbalanced action of those that remain tends to distort the foot. The object of the brace, in such cases, is to hold the foot so that the muscular traction, however applied, can move it only in the proper directions. The object of tendon or muscle transplantation is to utilize the muscular power that remains. Thus by giving an active muscle a new point of attachment where it may be of greatest service the brace may be dispensed with, or made less burdensome.

Tendon transplantation is, as the name implies, the operation of attaching the tendon of a living to that of a paralyzed muscle. The first operation was performed by Nicoladoni in 1882,[1] for the relief of paralytic calcaneus. The tendons of the peroneus longus and brevis were divided behind the external malleolus, and the proximal ends

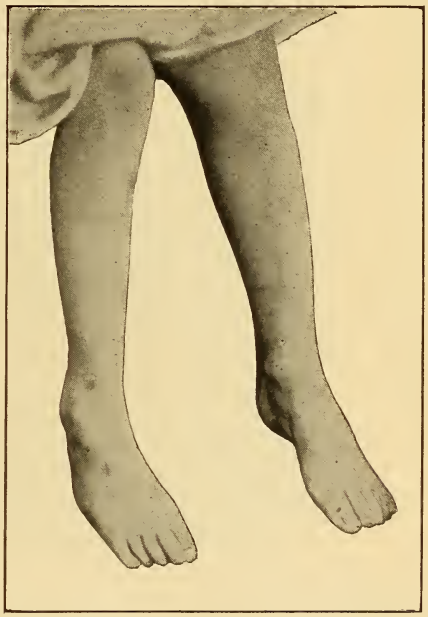
[1] Archiv f. Klin. Chir., 3, 27, S. 660, 1882.

united to the distal extremity of the divided tendo Achillis. The result is said to have been satisfactory.

The first operation on the front of the foot was performed by Parish,[1] of New York, for the relief of paralytic valgus, by sewing the tendon of the extensor proprius pollicis to that of the paralyzed tibialis anticus, without division of either tendon. In more recent years the field of the operation has been extended by Drobnik, of Posen,[2] Goldthwait,[3] of Boston, and others, to include almost every possible combination of tendons and muscles.

Tendon transplantation is most effective from the curative standpoint when but one muscle of the anterior leg group, for example an adductor or abductor, is paralyzed. The most common form of this milder type is paralysis of the tibialis anticus. As this muscle is the most powerful dorsal flexor and adductor of the foot its loss is followed by secondary equino-valgus. In Parish's operation the tendon of the adjoining extensor proprius pollicis was simply attached to that of the tibialis anticus, but as the extensor of the great toe is a very weak muscle, its power is hardly sufficient for the double task. A more efficient procedure is to split the tendon of the paralyzed muscle. The outer half is then separated from its muscular attachment, and the distal extremity is carried across the foot and is sutured to all the other tendons. The proprius pollicis is then attached to the inner half. In cases of longer standing and more marked deformity it is well to reduce the power of the abductors by cutting the tendon of the peroneus tertius from its insertion. This is then drawn beneath the other tendons and is attached to that of the tibialis anticus. All of the tendons on the front of the ankle may then be sutured to one another, so that all may act as direct dorsal flexors.

FIG. 444.



Paralytic equino-varus before operation. (See Fig. 445.)

If varus has resulted from paralysis of the peroneus tertius or brevis, or because of weakness of the extensors of the toes, while the

[1] N. Y. Med. Jour., Oct. 8, 1892.
[2] Centb. f. Chir., N. 7, July, 1894.
[3] Trans. Am. Orth. Ass'n, Vol. VIII., 1896.

the tibialis anticus retains its power its tendon may be split, the outer half having been separated at the distal end may be passed beneath the other tendons to be attached to the peroneus tertius, or a new attachment to the tissues on the outer border of the foot may be made. (Fig. 445.)

Every variety of combination has been employed. The tendon of the peroneus longus has been brought across the foot and attached to the tibialis anticus for the relief of valgus. The tendons of the flexor longus pollicis and of the peroneus brevis have been attached to the tibialis posticus and a portion of the inner part of the tendo Achillis has been utilized for the purpose of overcoming the same deformity.

Other operations on the back of the leg have been practically that of Nicoladini, the transplantation of the two peronei muscles into the

FIG. 445.

Paralytic equino-varus cured by operation, showing power of dorsal flexion (one half of the tendon of the tibialus anticus attached to the periosteum of the outer border of the foot). Operation July 19, 1898. The direct union of tendons to periosteum at the most advantageous point, has been urged recently by Lange (Ueber Periostale Schnenverplanzung bei Lähmung, Münch. med. Woch., No. 15, 1900).

tendo Achillis; or, as modified by Goldthwait, the tendon of the peroneus longus was inserted into the tendo Achillis and the brevis was transplanted into that of the flexor longus pollicis.

The operation of tendon transplantation should not be performed until the recovery from the paralysis is considered impossible. The incision should be sufficiently long to expose the tendon and the muscular substance. The paralyzed muscle is quite different in color from the normal, being dull reddish yellow, and the tendon is usually dull white in place of the silvery glistening color of the normal tendon. The splitting of the tendon should be begun high up, including, in some instances, muscle substance, and in joining the splices, as much

surface as possible of each splice should be apposed because the tendons do not readily unite.

Fine silk is usually employed for suturing. The tendon sheaths are, as far as possible, closed by fine catgut and the skin incision with the same material. Before the operation is performed, all resistance to normal motion should be overcome by force, and by division of the contracted parts, if necessary. The attachment of the muscles or tendons should be made while the foot is held in proper position, and in many instances, it is well to cut and overlap the paralyzed tendons to aid in retaining the foot in the improved attitude.

After the operation is completed, the foot should be fixed in a plaster bandage, in the over-corrected position, for several weeks or more.

FIG. 446.

Talipes equino-valgus after treatment by tendon transplantation. The tendon of the peroneus tertius was attached to the overlapped and shortened tendon of the tibialis anticus. All the tendons on the front of the foot were then united, so that all might serve as dorsal flexors.

As a rule, the foot should be supported by a brace until it is evident that the union of the parts is firm, and until the functional result is assured.

The prognosis will depend entirely upon the character of the paralysis. If the tibialis anticus is alone affected, sufficient power may be borrowed from the other muscles to lift the foot at least sufficiently to prevent awkwardness of gait, and to restrain deformity. Even more favorable is the prospect for the relief of varus, caused by weakness of the abductors, but it is impossible for weak muscles like the peronei, to supply the place of the great calf muscle or even to restrain the deformity of calcaneus. The power obtained from the peronei however, which has become useless and even harmful because it draws the foot into deformity, may be sufficient to hold the heel in proper

position and at least to aid the brace in retaining the foot in a normal attitude. The origin and insertion of the muscles, are shown in Figs. 340–350 inclusive.

The relative strength of the muscles, as well as their function, should be considered in selecting grafts, and in prognosis also. According to Fick, it is as follows, in kilogrammeters (see page 503):

BACK OF THE LEG.	
The calf muscle—gastrocnemius and soleus	8.21
Tibialis posticus	0.40
Peroneus longus	0.44
Flexor com. digitorum	0.37
Flexor longus pollicis	0.82
	10.24
FRONT OF THE LEG.	
Tibialis anticus	1.61
Extensor proprius pollicis	0.39
Extensor longus digitorum	0.72
Peroneus brevis	0.31
Peroneus tertius	0.20
	3.23

The importance of the calf muscle on the back, and tibialis anticus on the front of the leg, is apparent. The former is nearly four times as strong as the combined posterior group, the latter equal to all the others on the front of the leg.

It has been claimed that the transplanted muscle may become hypertrophied and that its strength may increase sufficiently to carry out its new function, but this is somewhat doubtful.

Direct transplantation of muscles on the same principle as tendon-grafting, has also been performed by Drobnik, Goldthwait and others; for example, the sartorius, the gracilis, or the tensor vaginæ femoris may be transplanted into the substance of the quadriceps extensor muscle. Drobnik has suggested the possibility of regenerating the paralyzed muscle by thus engrafting a portion of one that is still active, but this is a possible rather than a probable outcome.[1]

The principle of the operation applies of course to other parts of the body as well, but the opportunities for its application are far less frequent than in the lower extremities. The transplantation of certain of the over-active flexor muscles to the extensor aspect of the limb is sometimes of service in overcoming the deformities of spastic paralysis. The operation may be of especial service in the treatment of deformity of the hand in hemiplegia. (See page 464.)

The operation of tendon transplantation is often indicated, as is illustrated by the fact that it has been employed in fifty-five instances at the Hospital for Ruptured and Crippled during the past year. The author has always employed long incisions to thoroughly expose the muscles and fine silk for tendon sutures. Tendon transplantation has been combined, as a rule, with tendon shortening, and in many instances all

[1] It is impossible to formulate rules for tendon transplantation. The first essential is exact knowledge of the degree and distribution of the paralysis in the case to be treated, and of the function and strength of the muscles that remain. One may then decide how this power may be best applied, in order to balance the foot and to overcome deformity.

the tendons on the front of the foot have been sutured to one another, so that all the power might be utilized for dorsi-flexion. In certain cases the transplanted tendon may be united directly to the periosteum on the inner or on the outer side of the foot, instead of to the paralyzed tendon. Tendon transplantation may be combined also with other operations, such as astragalectomy, cuneiform osteotomy and the like.

Tendon Splicing.—Division and over-lapping of the tendons of paralyzed muscles may be employed with advantage in certain instances. For example, in complete paralysis of all the dorsal flexors of the foot, each tendon may be shortened and attached to the anterior ligament, thus the toe-drop may be remedied, or reduced to such an extent that the deformity may interfere but slightly with locomotion. As a rule however apparatus must be employed to prevent a recurrence of the deformity.[1]

Fig. 447.

A brace with a "limited" joint allowing slight motion at the ankle for paralysis or weakness.

Arthrodesis.

Arthrodesis, the removal of the cartilaginous surfaces of adjoining bones and thus inducing anchylosis for the relief of paralytic deformities of the foot, was first performed by Albert, of Vienna, in 1878. As applied to the foot, it is usually limited to those cases in which practically no muscular power remains, the so-called dangle foot. It may be of service also in cases of less disability as in equinus or calcaneus, when the patient is unable to provide himself with apparatus.

The operation consists in opening the joint and removing the cartilage from the apposed surfaces of the bones, then sewing or nailing them to one another, or simply fixing the parts in a plaster bandage until union has taken place. If the case is one of simple calcaneus or equinus, without lateral deviation, the operation may be limited to the ankle joint which may be opened from the back or front or side, as seems preferable. The cartilage is usually removed with a sharp spoon, and at the same time the relaxed tissues may be shortened after the Willett method, if the deformity be calcaneus; or the tendons on the

[1] Besides those mentioned in the text, the following are the more important articles on the subject of tendon transplantation: Hacker, Wiener Med. Presse, 1886. Phocas, Revue d'Orthopédie, T. 4, 1893. Winkleman, Zeits. für Chir., Bd. 39, S. 109. Milleken, N. Y. Medical Record, Dec., 1895. Ghillini, Zeits. für Orth. Chir., Bd. 4, 1896. F. Franke, Archiv für Klin. Chir., Bd. 52, H. 1; Bd. 57. Eulenburg, Deutsche med. Wochens., N. 14, 1898. Goelet, Zeits. für Orth. Chir., Bd. 7, H. 1, 1899. Hoffa, Berlin. klin. Wochens., N. 30, 1899.

front of the foot may be similarly shortened with the aim of lifting the toes to the proper level, if they are depressed. If, as in many instances, the deformity is equinuo-varus or valgus, the simple fixation at the ankle joint will be insufficient and it must be supplemented by arthrodesis of one or more of the anterior articulations.

In cases of calcaneo-valgus, the removal of the astragalus will be found to be a useful operation, since it improves the stability of the joint, and the limitation of motion is usually sufficient to prevent deformity. If the astragalus is not removed, the operation must include the fixation of the astragalo-scaphoid, and the medio-tarsal as well as of the ankle joint, and, if toe-drop is extreme, of the tarsal joints also.

The method of operating depends upon the deformity. In simple arthrodesis of the ankle joint for toe-drop, the joint may be opened by a perpendicular incision over the front of the ankle.

For calcaneus, the posterior incision may be employed, if it is intended to shorten the tissues after the Willett method in connection with the arthrodesis.

Both the ankle and the calcaneo-astragaloid joints can be opened from the back, although the upper one may be more easily reached from the front. If it is necessary to fix the medio-tarsal joint as well as the ankle joint, a curved incision may be made beneath the inner malleolus to the middle of the foot; or if the foot is in varus, the incision may be made on the outer side. The cartilaginous surfaces of the bones must be completely removed if firm anchylosis is to be obtained. The parts may be fixed with sutures or nails, but this is unnecessary if accurate opposition can be obtained. The foot is fixed by means of a plaster bandage in the line of the leg, slightly dorsi-flexed, and as soon as possible the patient is encouraged to use the part.

The improvement in the gait, obtained by the rectification of deformity and by fixation of the foot, is often very marked, and in many instances support may be discarded. But, in early childhood at least, the patients should, if possible, be kept under observation, in order that support may be applied if the deformity shows a tendency to recur.

Arthrodesis is also performed at the knee and at other joints for the purpose of fixing the part in a useful attitude. In certain instances, the operation is indicated. It is, of course, limited to cases of hopeless paralysis and it is more suitable to the older than the younger class of patients.[1]

[1] The more important articles on arthrodesis are the following: Bidone, Archiv di Ortoped., Fasc. 6, 1894. Samter, Centb. für Chir., 1895, N. 21, S. 497. Karewski, Centb. für Chir., 1895, N. 25, S. 593. Jones, The International Medical Annual, 1895, p. 407. Karasiewicz, Inaug. Diss. Königsberg, 1894. Broca, Revue d'Orthopédie, Nov., 1894. Roersch, Revue de Chir., 1892, No. 6. Kirmisson, Revue d'Orthopédie, N. 2, 1896. Popper, Wiener klin. Rundschau, N. 20, 1900.

INDEX.

ABSCESS in extra-articular tuberculous joint disease, 199
in hip disease, see Abscess in Tuberculous Disease Hip Joint, 255
pelvic, in lumbar Pott's disease, 40
in Pott's disease, 87
in different regions, 88
treatment of, 89
in sacro-iliac disease, 119
secondary, in tuberculous joint disease, 200
in thoracic region, 49
in tuberculous disease of ankle joint, 334
of hip joint, 285
frequency of, 285
significance of, 286
treatment of, 287
by aspiration, 288
by incision, 288
by injection, 288
of knee joint, 318
statistics of, 318
treatment of, 318
by aspiration, 318
by incision, 318
of shoulder joint, 350
Absent patella, 329
Achillo-bursitis, 544
etiology of, 545
pathology of, 545
symptoms of, 545
treatment of, 546
brace in, 546
operative, 546
posterior, 547
symptoms of, 547
treatment of, 547
Achillodynia, see Achillo-bursitis, 544
Achondroplasia, see Fœtal Rhachitis, 367
Acquired genu recurvatum, 332
Acquired talipes, 609
calcaneus, 616
astragalectomy for, 620
development of deformity of, 617
symptoms of, 618
treatment of, 618
operative, 619
Willett's operation for, 619
development of deformity in, 609
Acquired talipes, differential diagnosis in, 610
equino-valgus, 623
treatment of, 623
equino-varus, 623
treatment of, 623
cuneiform osteotomy in, 623
equinus, 611
etiology of, 612
immediate correction of deformity of, 614
Thomas wrench for, 614
tonic effect of, 615
prognosis, 613
symptoms of, 612
treatment of, 613
Shaffer extension brace in, 614
etiology of, 609
Acquired torticollis, 479
Acromegalia, 371
diagnosis of, 371
symptoms of, 372
Actinomycosis of spine 108
Acute torticollis, 479
Amputations, spontaneous, congenital, 608
Anchylosis, 218
etiology, 218
pathology, 218
prevention of, 219
treatment of, 219
by forcible correction, 220
operative exploration in, 220
by passive motion, 220
Ankle joint, tuberculous disease of, 334
sprain of, 342
chronic, 344
treatment, 345
symptoms, 342
treatment, 343
by plaster bandage, 343
by plaster strapping, 343
Anterior bow leg, 428
symptoms of, 429
treatment, 429
Anterior curvature of tibia, see Anterior Bow Leg, 428
Anterior dislocation of hip, 380
Anterior displacement of the tibia, see Congenital Genu Recurvatum, 328
Anterior metatarsalgia, 538
complications of, 542

Anterior metatarsalgia, etiology of, 538
influence of shoe in causing disability and pain in, 541
pathology of, 538
treatment of, 542
brace for, 543
support in, 543
Anterior poliomyelitis, acute, 440
causes of deformity of, 445
deformities of upper extremity in, 447
of neck in, 447
of trunk in, 448
secondary in, 449
diagnosis of, 443
differential, 443, 444
etiology, 441
pathology, 440
prognosis, 444
retardation of growth in, 449
statistics of, 441
tables of, 441, 442
symptoms of, 442
treatment of, 450
mechanical principles of, 450
prevention of deformity in, 450
arthrodesis in, 456, see Talipes
osteotomy in, 457
paralysis in, 444
of anterior muscles of leg, in 450, see Talipes
paralysis of arm in, 455
electrical test for, 445
muscles of hip in, 454
of posterior muscles of leg in, 451
of thigh muscles in, 451
paralytic scoliosis in, 454
reduction of deformity of, 455
by braces, 456
tendon transplantation in, 456
treatment, operative, 455, 457
Arborescent synovial tuberculosis, 201
Arthectomy in tuberculous disease of knee joint, 319
advantage of, 319
results of, 319
statistics of, 319
table of shortening, 320
Arthritis, acute, of infancy, 211
deformans, see Osteo-arthritis, 212
following infectious disease, 210
operative intervention in, 211
treatment of, 211
typhoid fever, 211
statistics of, 211
gonorrhœal, 208
statistics of, 208
symptoms of, 208
treatment of, 210
varieties of, 209
infectious, of knee joint, 325
Arthritis, infectious, treatment of, 325
puerperal, 210
rheumatoid, of knee joint, 325
of spine, 111
chronic rheumatoid, 113
treatment of, 111
tuberculous, acute, 212
Arthrodesis, 629
description of operation, 629
for toe drop, 630
in treatment of anterior poliomyelitis, 456, see Talipes
Astragalectomy in treatment of calcaneus, 620
in treatment of club foot, 598
Asymmetrical development, 189
Ataxia, hereditary, 468
symptoms of, 469
Atrophy, muscular progressive, 466

BACK knee, see Genu Recurvatum, Acquired, 332
lower part of, pain in, 116
treatment of, 116
Bands, constricting, congenital, 608
Bending of neck of femur, see Coxa Vara, 392
Bier's treatment, see Venous Stasis, 205
Bilateral coxa vara, 397
dislocation of hip, 379
Billroth splint in treatment of tuberculous disease of knee joint, 313
Bow leg, see Genu Varum, 405, 423
anterior, 428
Braces in treatment of lateral curvature of spine, 148, 176
Bradford frame, 60, 271
in treatment of rhachitis, 366
Bursæ in popliteal region, 326
Bursitis, chronic, at shoulder, 359
prepatellar, 325
pretibial, 326

CALCANEO-BURSITIS, 547
symptoms of, 547
treatment of, 547
Caliper brace in treatment of tuberculous disease of knee joint, 317
description of, 317
Calot's operation, 101–103
Campbell brace, in treatment displacement semilunar cartilage in knee, 327
Caput quadratum, 363
Cerebral paralysis of childhood, 459
Cervical opisthotonos, 491
Charcot's disease, 217
diagnosis, 217
distribution, 217
pathology, 217
statistics of, 217
symptoms, 217
treatment, 218
Chest, circumference of, table of, 190
deformities of, 186
flat, 186
treatment of, 186

Chest, funnel, 187
pigeon, 186
treatment of, 187
Chondrodystrophia, see Fœtal Rhachitis, 367
Clavicle, absence or defect of, 188
acquired luxation of, 188
treatment of, 188
Club hand, 434
etiology, 434
statistics of, 435
treatment of, 436
operative, 436
Club foot, astragalectomy in treatment of, 598
confirmed, correction of, method Julius Wolff, 593
congenital, anatomy of, 569
symptoms of, 572
treatment of, 572
cuneiform osteotomy in treatment of, 599
division of the tendo Achillis in treatment of, 592
forcible correction of deformity of, by osteoclasts, 596
by Phelps' operation, 596
by Thomas method, 595
manual correction of, 585
hysterical, 470
differential diagnosis of, 471
infantile, principles of treatment of, 573
rectification of deformity of, 574
treatment of, mechanical, 574
by plaster bandage, 575
by splints and braces, 577
retention brace in, 581
tenotomy in, 579
malleotomy in treatment of, 591
mechanical rectification of deformity of, 600
Judson brace for, 600
osteotomy in treatment of, 598
secondary treatment of, 600
rapid correction of deformity of, 585
subcutaneous tenotomy in treatment of, 591
treatment of, division of plantar fascia in, 593
of tibialis anticus in, 593
posticus in, 593
Congenital absence of fibula associated with talipes equino-valgus, 606
etiology of, 607
statistics of, 606
treatment of, 607
Congenital absence of tibia associated with talipes varus, 607
prognosis of, 607
statistics of, 607
treatment of, 607
club foot, 569
contraction of fingers, 437
treatment of, 437
at knee, 332
deficiency and hypertrophy, 607
deformities of elbow, 433
at wrist, 434
dislocation of hip, see Hip Joint, Congenital Dislocation of, 373
of shoulder, 430
treatment of, 430
displacement of patella, 329
elevation of scapula, 185
etiology of, 185
treatment of, 186
genu recurvatum, 328
hallux varus, see Pigeon Toe, 551
lateral curvature of spine, 135
œdema of feet, 608
talipes calcaneus, 604
statistics of, 604
treatment of, 604
equinus, 604
statistics of, 604
valgus, 605
statistics of, 605
varus, 603
torticollis, 475
Constricting bands, congenital, 608
Contracted foot, see Hollow Foot, 534
Contraction of fingers, congenital, 437
treatment of, 437
confirmed club foot, method Julius Wolff, 593
Coxa vara, 392
bilateral, 397
diagnosis of, 398
etiology of, 393
mechanical effects of, 394
predisposition to deformity of, 393
pathology of, 393
physical effects of, 396
statistics of, 394
table of, 395
symptoms of, 394
traumatic, 402
diagnosis of, 402
treatment of, 402
treatment of, 399
apparatus in, 400
operative, 400
cuneiform osteotomy, 401
linear osteotomy, 400
unilateral, symptoms of, 396
Craniotabes, 363
Cretinism allied to fœtal rhachitis, 367

Cubitus valgus, 433
varus, 433
Cuneiform osteotomy, in treatment of anterior bow leg, 429
of club foot, 599
of coxa vara, 401
of genu valgum, 422
of hallux valgus, 554
of talipes, 599
Cysts in popliteal region, 326

DEPRESSION of neck of femur, see Coxa Vara, 392
Development, asymmetrical, 189
normal, tables of, 190
Diagnosis of Achillo-bursitis, 545
of acquired talipes, 610
of acromegalia, 371
of actinomycosis of spine, 108
of anterior metatarsalgia, 538
of acute epiphysitis at hip, 301
anterior poliomyelitis, 443
torticollis, 482
of calcaneo-bursitis, 547
of Charcot's disease, 217
of congenital dislocation of hip joint, 380
elevation of scapula, 183
paralysis, 461
of coxa vara, 398
unilateral, 397
bilateral, 398
of displacement of peronei tendons, 555
of erythromelalgia, 548
of fracture of neck of femur, 402
of functional affections of joints, 472
of gluteal bursitis, 302
of gonorrhœal arthritis, 209
of hallux rigidus, 549
of hollow foot, 535
of hysterical club foot, 470
hip, 469
of injury of spine, 108
of lateral curvature of spine, 141
of malignant disease of spine, 107
of obstetrical paralysis, 431
of osteo-arthritis, 215
arthropathy, 371
of osteitis deformans, 371
of periarthritis of shoulder, 358
of poliomyelitis, anterior, 442
of Pott's paraplegia, 96
of pseudo-hypertrophic muscular paralysis, 468
of rhachitic spine, 109
of rhachitis, 365
of sacro-iliac disease, 118
of sciatic scoliosis, 117
of spondylitis deformans of spine, 113
of syphilis of spine, 107
of torticollis, 482
of traumatic coxa vara, 402
of tuberculous disease ankle joint, 339
elbow joint, 351
hip joint, 244
Diagnosis of tuberculous knee joint, 310
shoulder joint, 350
of spine, 41, 50, 54
sub-astragaloid joint, 339
of tarsus, 341
of typhoid spine, 110
of weak foot, 514
Dislocation of hip, congenital, see Hip Joint, Congenital Dislocation of 373
of shoulder, congenital, 430
treatment of, 430
recurrent, 432
treatment of, 432
operative, 433
Displacement of peronei tendons, 555
treatment of, 556
"Double joints," 363
Dupuytren's contraction, 438
etiology of, 439
pathology of, 439
symptoms of, 439
treatment of, 439
Dystrophy, muscular, 467

ELBOW, congenital deformities of, 433
excision of, in tuberculous disease of, 353
joint, tuberculous disease of, 351
Elongation ligamentum patellæ, 331
Epiphysis of head of femur, traumatic separation of, 404
Epiphysitis, acute, 211
distribution of, 211
etiology of, 211
prognosis, 212
statistics of, 211
symptoms of, 212
treatment of, 212
Equino-varus, hysterical, 624
Erythromelalgia, 548
Exercise in treatment of lateral curvature of spine, 151, 164
Exostoses of foot, 555
Etxra-articular disease of hip, 301
of knee, 318

FEMUR, bending of neck of, see Coxa Vara, 392
depression of neck of, see Coxa Vara, 392
fracture of neck of, 402
Fingers, congenital contraction of, 437
treatment of, 437
distortions of, 438
drop, see Mallet Finger, 438
jerking, see Trigger Finger, 438
mallet, see Mallet Finger, 438
snapping, see Trigger Finger, 438
trigger, see Trigger Finger, 438
webbed, 437
etiology of, 437
treatment of, 437
Flat foot, see Weak Foot, 507
Fœtal rhachitis, 367
cretinism allied to, 367

Fœtal rhachitis, etiology, 367
pathology, 367
prognosis, 367
treatment of, 367
Foot, contracted, 534
deformities of, 492
disabilities of, 492
flat, see the Weak Foot, 507
function of the muscles of, 502
general description of, 492
hollow, 534
exostoses of, 555
as a mechanism, 506
movements of, 496
plaster cast of, method of taking, 524
relative strength of muscles of, tables of, 503
splay, see Weak Foot, 507
weak, 507
adjuncts in treatment of, 532
plaster strapping, 532
Thomas treatment, 532
anatomy of, 508
in childhood, 519
out and in toeing as symptoms of, 519
diagnosis of, 514
etiology of, 511
extreme types of, 517
operative treatment for, 532
pathology of, 511
rigid, 527
other varieties of, 531
treatment of, 527
forcible over-correction in, 527
systematic manipulation in, 527
statistics of, 512
symptoms of, 513
treatment of, 521
attitudes in, 522
brace in, 525
exercises in, 523
the shoe in, 521
support in, 523
varieties of, 516
Fracture of neck of femur, 402
Fragilitas ossium, 368
Freidreich's disease, see Hereditary Ataxia, 468
Functional affections of joints, 471
causes of, 472
diagnosis of, 472
treatment of, 472
pathogenesis of deformity, 190
Funnel chest, 187

GENU recurvatum, acquired, 332
etiology of, 332
symptoms of, 333
treatment of, 333
congenital, 328
treatment of, 329
deformities accompanied by, 328
statistics of, 328
Genu recurvatum, deformities accompanied by, etiology of, 329
Genu valgum, 405–411
accommodative attitude in, 414
combined with general rhachitic distortions, 415
with genu varum, 415
etiology of, 406
gait in, 414
measurements of deformity of, 417
outgrowth of deformity of, 409
pathology, 416
predisposition to deformity of, 409
secondary deformities of, 414
statistics of, 405
table of, 406
time of onset of, 406
treatment of, 417
by braces, 419
duration of, 420
exercise in, 418
expectant, 417
manipulation in, 417
Lorenz's operation, 423
operative, 421
osteoclasis in, 422
osteotomy in, 421
cuneiform, 422
by plaster bandage, 421
posture in, 418
Thomas brace in, 420
Wolff's, 423
unilateral, 415
Genu varum, 405, 423
etiology of, 406
measurements of deformity in, 426
outgrowth of deformity of, 409
predisposition to deformity in, 406
statistics of, 405
table of, 405
symptoms of, 425
time of onset of, 406
treatment of, 426
by braces, 426
expectant, 426
operative, 426
osteotomy in, 427
osteoclasis in, 427
Gonorrhœal arthritis, 208
statistics of, 208
symptoms of, 208
treatment of, 210
varieties of, 209
Gonorrhœal rheumatism, see Gonorrhœal Arthritis, 208
of spine, 111

HÆMARTHROSIS, 217
Hæmophilia, 216
treatment, 217
Hallux flexus, see Hallux Rigidus, 548
rigidus, 548

Hallux rigidus, etiology of, 549
treatment of, 549
Hallux valgus, 551
etiology of, 552
pathology of, 552
symptoms of, 553
treatment of, 553
cuneiform osteotomy in, 554
operative, 553
Hallux varus, 551
congenital, see pigeon toe, 551
treatment of, 551
Hammer toe, 554
symptoms of, 554
treatment of, 554
Height, table of, 190
Hemiplegia, treatment of, 463
Hereditary ataxia, 468
symptoms of, 469
"High hip" of lateral curvature of spine, 125
"shoulder" of lateral curvature of spine, 125
Hip disease, see Tuberculous Diseases of Hip Joint, 221
excision of, in tuberculous disease of hip joint, 290
functional results after, 290, 292
statistics of, 289, 291
Hip, hysterical, 469
anterior dislocation, 380
bilateral dislocation of, 379
general symptoms of, 380
congenital dislocation of, 373
diagnosis of, 380
etiology, 377
pathology, 374
statistics, 373
table of, 374
symptoms, 378
treatment of, 382
intermediate operation, 390
Lorenz's operation in, 386
open operation in, 383
secondary osteotomy in, 391
tuberculous disease of, 221
unilateral dislocation of, 378
Hollow foot, 534
etiology of, 534
symptoms of, 535
treatment of, 537
operative of, 537
Housemaid's knee, see Prepatellar Bursitis, 325
Hutchinson's index showing relative depth of chest, 186
Hysterical club foot, 470
differential diagnosis, 471
Hysterical equino-varus, 624
hip, 469
diagnosis of, 469
differential, 470
symptoms of, 470
scoliosis, 471
case of, 471
treatment of, 471
spine, 115
symptoms of, 115
treatment of, 116

IDIOPATHIC osteopsathyrosis, see Fragilitas Ossium, 368
Incidental lateral curvature of spine, 135
Infantile club foot, 573
paralysis, see Poliomyelitis Anterior, 440
scorbutus, 367
pathology of, 368
symptoms of, 368
treatment of, 368
In knee, see Genu Valgum, 405–411
Injury of sacro-iliac articulation, 119
of spine, 55, 108
Intermediate operation, for congenital dislocation of hip, 390

JERKING finger, see Trigger Finger, 438
Joint disease in locomotor ataxia, 218
in affections of nervous system, 217, 218
Joints, diseases of, syphilitic, 206
acquired, 207
hereditary, 206
later manifestations in, 207
pseudo-paralysis in, 206
spina ventosa in, 207
treatment of, 208
functional affections of, 471
causes of, 472
diagnosis of, 472
treatment of, 472
neurotic, see Joints, Functional Affections of, 471
Judson brace in treatment of club foot, 600
hip brace, 255

KINGSLEY'S table for estimating flexion deformity, 244
Knee, congenital contraction at, 332
general contractions combined with, 332
prognosis of, 332
treatment of, 332
displacement of a semilunar cartilage in, 327
cause of, 327
treatment of, 327
Campbell brace in, 327
extra-articular disease of, 318
injuries of, in childhood, 324

Knee joint, internal derangement of, 326
loose bodies in, 326
tuberculous disease of, 304
snapping, 331
treatment of, 332
strains of, in childhood, 324
Knight brace in treatment, lateral curvature of spine, 177
Knock knee, see Genu Valgum, 405–411
Kyphosis, 182
of adolescents, 114
postural, 183
of rhachitis, 109, 183
treatment of, 184

LAMINECTOMY, 98
Latent tuberculosis, 194
Lateral curvature of spine, 120
congenital, 135
diagnosis of, 141
mobility tests of, in, 142
posture in, 141
due to occupation, 135
effects of deformity of, 124
fixed deformity in, 121
forcible correction of deformity of, 177
combined with fixation, 178
habitual deformity in, 121
hereditary influence in, 137
the "high hip" of, 125
"shoulder" of, 125
incidental, 135
lateral deviation in, 124
occupation as a factor in, 137
pathology of, 126
prevention of deformity of, 146
prognosis of, 143
record of case, 142
rhachitic, 135
rotation in, 123
secondary to deformity elsewhere, 133
to disease within thoracic walls, 134
to paralysis, 133
statistics of, 130
age, 131
frequency, 130
sex, 130
symptoms of, 141
treatment of, 147
by braces, 148, 176
corsets in, 177
duration of, 180
exercises in, 151, 164
general, 180
high shoe in, 180
Knight brace in, 177
self-suspension in, 175
Teschner's exercises in, 151
Volkmann seat in, 180
varieties of deformity in, 139
"Late rickets," 366
Ligamentum patellæ, elongation of, 331
etiology, 331
symptoms, 331
treatment, 331
Linear osteotomy in treatment of coxa vara, 400
Lipoma, arborescens tuberculosum, 201
Locomotor ataxia, joint disease in, 218
Lordosis, 184
treatment of, 185
Lorenz operation, for congenital dislocation of hip, 386
for genu valgum, 423
reclination gypsbettes in treatment, Pott's disease, 60
Lovett's table for estimating lateral distortion in tuberculous disease, hip joint, 242
Lumbar Pott's disease in infancy, peculiarities of, 44

MALIGNANT disease of spine, 107
diagnosis of, 107
Malleotomy in treatment of club foot, 591
Mallet finger, 438
Metatarsalgia, anterior, 538
etiology of, 538
influence of shoe in causing disability and pain in, 541
pathology of, 538
treatment of, 542
brace for, 543
support in, 543
Metzger-Goldthwait apparatus, 105
Mollitis ossium, see Osteomalacia, 369
Morbus coxæ, see Tuberculous Disease of Hip Joint, 221
Morton's neuralgia, see Metatarsalgia Anterior, 538
Muscles of leg, relative strength of, 628
pectoral, defective formation of, 188
Muscular atrophy, progressive, 466
dystrophy, 467
Myelopathic paralysis, 466

NECK, deformities of, in anterior poliomyelitis, 447, see torticollis, 474
Nervous system affections of, joint disease in, 217, 218
diseases of, 440
Neuritis, 469
treatment of, 469
Neurotic joints, see Joints, Functional Affections of, 471
spine, 114
symptoms of, 115
treatment of, 115
Non-deforming club foot, see Hollow Foot, 534
Non-tuberculous affections of the ankle joint, 342
of the hip joint, 300
of the knee joint, 324
of the spine, 107
disease of joints, 206

OBSTETRICAL paralysis, 431
treatment of, 431
Ocular torticollis, 491
Œdema of foot, congenital, 608
Open operation, for congenital dislocation of hip, 383
Osteitis deformans, 370
deformities of, 370
of spine, 114
Osteo-arthritis, 212
atrophic form, 214
etiology of, 213
of knee joint, 325
symptoms of, 325
treatment of, 325
localized form, 214
multiple form, 213
statistics of, 214
pathology, 212
of spine, see spondylitis deformans, 111
case of, 113
symptoms of, 215
treatment of, 215
by apparatus, 216
by forcible manipulation, 216
varieties of, 213
Osteo-arthropathy, 370
treatment of, 371
Osteoclasis in treatment of genu valgum, 422
in treatment of genu varum, 427
in treatment of talipes, 596
Osteomalacia, 369
in childhood, 369
cases of, 369
treatment of, 370
deformities of, 369
symptoms of, 369
Osteomyelitis, infectious localized, 212
of spine, 108
symptoms of, 108
treatment of, 108
Osteotomy for correction deformity of tuberculous disease hip joint, 293
cuneiform in treatment of club foot, 599
in treatment of coxa vara, 401
in treatment of hallux valgus, 554
linear in treatment of coxa vara, 400
secondary in treatment, anterior poliomyelitis, of club foot, 600
in treatment of, 457
of club foot, 598
of genu valgum, 421
varum, 427
Over-lapping toes, 555

PAGET'S disease, 370
see osteitis deformans of spine, 114
Painful great toe, see Hallux Rigidus, 548
joint in older subjects, 550
heel, 547
Pain in lower part of back, 116
treatment of, 116
Paralysis, acquired, 459, 462
deformities in, 462
disability of, 463
loss of growth in, 463
Sach's classification of causes and effects of, 459
of anterior muscles of leg in anterior poliomyelitis, 450, see Talipes Poliomyelitis, 444
of arm in anterior poliomyelitis, 455
cerebral, in childhood, 459
congenital, 459, 461
deformities in, 462
electrical test for, in anterior poliomyelitis, 445
infantile, see Poliomyelitis, Anterior, 440
muscles of hip in anterior poliomyelitis, 454
myelopathic, 466
Aran-Duchenne type of, 466
Charcot-Marie-Tooth type of, 466
myopathic, 467
obstetrical, 431
treatment of, 431
of posterior muscles of leg in anterior poliomyelitis, 451
in Pott's disease, 93
pseudo-hypertrophic muscular, 468
diagnosis of, 468
treatment of, 468
spastic, 459
etiology of, 459
pathology of, 459
prognosis of, 466
statistics of distribution of, 459
statistics of mental impairment in, 461
symptoms of, 460
mental, 460
motor, 460
of thigh muscles, anterior poliomyelitis, 451
Paralytic scoliosis in anterior poliomyelitis, 454
torticollis, 491
Paraplegia, treatment of, 93, 464
Patella, congenital displacement of, 329
rudimentary or absent, 329
treatment of, 329
slipping, 330
etiology, 330
symptoms, 330
treatment, 330
operative, 330
Pathogenesis of deformity, functional, 190
Pectoral muscles, defective formation of, 188
Pectus carinatum, see Pigeon Chest, 186
excavatum, see Funnel Chest, 187
Pelvic abscess in lumbar Pott's disease, 40
Periarthritis of the shoulder, 358
symptoms of, 358
treatment of, 358
Peronei tendons, displacement of, 555

Pes planus, 518
Phalanges, congenital displacement of, 438
Phelps' bed in treatment Pott's disease, 60
hip splint, 278
operation for immediate correction of deformity of club foot, 596
Pigeon breast, 364
chest, 186
treatment of, 187
toe, 551
Plantalgia, see Plantar Neuralgia, 548
Plantar fascia, division of, in treatment of club foot, 593
of hollow foot, 537
Plantar neuralgia, 548
treatment of, 548
Plaster bandage in treatment tuberculous disease hip joint, 265, 266
cast of foot, method of taking, 524
corset, 76
jacket, application of, 70
in recumbency, 74
Poliomyelitis, anterior, acute, 440
causes of deformity of, 445
deformities of lower extremity in, 450
of neck in, 447
secondary in, 449
of trunk in, 448
of upper extremity in, 447
diagnosis of, 443
differential, 443, 444
etiology of, 441
pathology of, 440
prognosis of, 444
retardation of growth in, 449
statistics of, 441
tables of, 441, 442
symptoms of, 442
treatment of, 450
mechanical, principles of, 450
prevention of deformity in, 450
arthrodesis in, 456
osteotomy in, 457
paralysis in, 444
of anterior muscles of leg in, 450
of arm in, 455
electrical test for, 445
of posterior muscles of leg, 451
of thigh muscles, 451, 454
paralytic scoliosis in, 454
torticollis in, 490
reduction of deformity of, 455
by braces, 456
tendon transplantation in, 456
treatment of, operative, 455, 457
Popliteal region, bursæ and cysts in, 326
Posterior torticollis, 491
Pott's disease, see Tuberculous Disease of Spine, 17
complications of, 87
abscess, 87
in different regions, 88
treatment of, 89
paralysis in, 93
duration of, 95
prognosis, 95
statistics of frequency of, 93
liability to, in different regions, 94
time of onset, 95
symptoms of, 95
treatment of, 97
duration of, 99
operative, 98
forcible correction deformity of, 101
statistics of results of, 102
selection of cases for, 102
gradual correction of deformity of, 104
Metzger-Goldthwait apparatus for, 105
local paralysis in, 98
recurrence of, 100
secondary deformities, 100
statistics of, 21
age, 22
frequency, 21
sex, 22
situation, 22
Pott's fracture, 624
Pott's paraplegia, 95
symptoms of, 95
Pretibial bursa, enlargement of superficial, 326
Prepatellar bursitis, 325
treatment of, 325
Pretibial bursitis, 326
symptoms of, 326
treatment of, 326
Progressive muscular atrophy, 466
Pseudo-hypertrophic muscular paralysis, 468
diagnosis of, 468
treatment of, 468
Pseudo-paralysis in rhachitis, 34
in syphilitic disease, 206
Psychical torticollis, 491
Puerperal arthritis, 210

RETENTION brace in treatment of club foot, 581
Retro-calcaneo bursitis, see achillo-bursitis, 544
Rhachitic distortions, general, 429
kyphosis, 109
lateral curvature of spine, 135
rosary, 363
spine, 45, 109, 110, 183, 364
treatment of, 110

Rhachitic torticollis, 491
Rhachitis, 361
deformities of, 362
caput quadratum, 363
"craniotabes," 363
"double joints," 363
pigeon breast, 364
"rhachitic rosary," 363
attitude, 364
pseudo-paralysis, 364
spine, 45, 109, 110, 183, 364
etiology of, 361
fœtal, 367
cretinism allied to, 367
etiology, 367
pathology, 367
prognosis, 367
treatment of, 367
kyphosis of, 109, 183
pathology of, 361
prognosis of, 365
symptoms of, 362
treatment of, 365
Bradford frame in, 366
prevention of deformity in, 366
Rheumatism of spine, 56, see also Spondylitis Deformans, 111
Rheumatoid arthritis, see Osteo-arthritis, 212
of knee joint, 325
of spine, chronic, 113
Ribs, absence of, 188
Rice bodies in tuberculous joint disease, 201
Rickets, see Rhachitis, 361
Rigid flat foot, see Rigid Weak Foot, 527
weak foot, 527
treatment of, 527
forcible over-correction in, 527
plaster strapping in, 532
systematic manipulation in, 527
Thomas, 532
Rotary lateral curvature, see lateral curvature of the spine, 120
Rudimentary patella, 329

SACRO-ILIAC articulation, injury of, 119
disease of, 117
abscess in, 119
diagnosis of, 118
prognosis of, 118
symptoms of, 117
treatment of, 118
Thomas hip brace in, 119
Scapula, congenital elevation of, 185
etiology of, 185
treatment of, 186
Sciatica, deformity secondary to, 117, 119
Sciatic scoliosis, see Sciatica, Deformity Secondary to, 117
Scoliosis, see Lateral Curvature of Spine, 120
Scoliosis, hysterical, 471
case of, 471
treatment of, 471
paralytic in anterior poliomyelitis, 454
total, 122
Scorbutus, hemorrhage in, 217
infantile, 367
symptoms of, 368
treatment of, 368
Scurvy, see Scorbutus, Infantile, 367
rickets, see Scorbutus, Infantile, 367
Secondary, hypertrophic osteo-arthropathy, 370
Shoes, 556
Shoulder, chronic bursitis at, 359
congenital dislocation of, 430
treatment of, 430
joint, tuberculous disease of, 348
periarthritis of, 358
symptoms of, 358
treatment of, 358
recurrent dislocation of, 432
treatment of, 432
operative, 433
Sinuses in tuberculous disease hip joint, treatment of, 289
Slipping patella, 330
Snapping finger, see Trigger Finger, 438
knee, 331
Spasmodic torticollis, 486
Spastic paralysis, 459
torticollis, 480
Spina bifida and talipes, 608
ventosa, 356
statistics of, 356
in syphilitic disease, 207
treatment, 357
operative, 357
Spine, actinomycosis of, 108
antero-posterior deformities of, 182
kyphosis, 183
postural, 183
of rhachitis, 109, 183, 364
lordosis, 184
treatment of, 185
treatment of, 184
arthritis of, 111
treatment of, 111
changes in antero-posterior contour of, 125
contour and flexibility of normal, 29
variations in, 181
divisions of, 30
injury of, 55, 108
gonorrhœal rheumatism of, 111
hysterical, 115
symptoms of, 115
treatment of, 116
landmarks of, 32
lateral curvature of, 120
congenital, 135
diagnosis, 141
mobility tests of, in, 142
posture in, 141

Spine, lateral posture in, due to occupation, 135, 137
effects of deformity of, 124
fixed deformity in, 121
forcible correction of deformity in, 177
combined with fixation, 178
habitual deformity in, 121
hereditary influence in, 137
the "high hip" of, 125
"shoulder" of, 125
incidental, 135
lateral deviation in, 124
pathology of, 126
prevention of deformity in, 146
prognosis of, 143
record of case, 142
rhachitic, 135
rotation in, 123
secondary to deformity elsewhere, 133
to disease within thoracic walls, 134
to paralysis, 133
statistics, 130
age, 131
frequency, 130
sex, 130
symptoms of, 141
treatment of, 147
by braces, 148, 176
corsets in, 177
duration of, 180
exercise in, 151, 164
Teschner's, 151
general, 180
Knight brace in, 177
high shoe in, 180
self-suspension in, 175
Volkmann seat in, 180
varieties of deformity in, 139
malignant disease of, 107
diagnosis of, 107
neurotic, 114
symptoms of, 115
treatment of, 115
osteitis deformans of, 114
osteo-arthritis of, see Spondylitis Deformans, 111
case of, 113
osteomyelitis of, 108
symptoms of, 108
treatment of, 108
physiological movements of, 120
rhachitic, 45, 109, 110, 183, 364
treatment of, 110
rheumatism of, see Spondylitis Deformans, 111
rheumatoid arthritis of, case of, 113
syphilis of, 107
diagnosis of, 107
traumatic spondylitis, 109
tuberculous disease of, 17
typhoid, the, 110
Spine, typhoid, the, treatment of, 110
variations in contour of, 181
Splay foot, see Weak Foot, 507
Spondylolisthesis, 116
Spondyloze Rhizomélique, see Spondylitis Deformans, 111
Spondylitis deformans, 111
case of, 113
pathology of, 111
symptoms of, 112
treatment of, 114
traumatic, 109
Spontaneous amputations, congenital, 608
Sprain of the ankle, 342
chronic, 344
of wrist, 359
chronic, 359
Sprengel's deformity, see congenital elevation of scapula, 185
Statistics of anterior poliomyelitis, 441
of club hand, 435
of congenital dislocation at hip joint, 373
talipes calcaneus, 604
equinus, 604
valgus, 605
calcaneo-valgus, 605
equino-valgus, 605
associated with congenital absence fibula, 606
varus associated with congenital absence tibia, 607
of coxa vara, 394
genu valgum, 405
varum, 405
lateral curvature of spine, 130
age, 131
frequency, 130
sex, 130
varieties, 140
of osteo-arthritis, 214
of Pott's disease, 21
age, 22
frequency, 21
sex, 22
situation of, 22
of results of tuberculous joint disease, 203, 295, 298, 322, 323, 341, 349, 354
of spina ventosa, 356
of synovial disease of joints, 201
of talipes, 566
foot affected, 567
relative frequency of different forms, acquired, 568
congenital, 567
comparative frequency of different forms, congenital and acquired, 568
sex, 567
of torticollis, 474
acquired, 481
table of, 481
spasmodic, 487

Statistics of tuberculous disease of elbow joint, 351, 354
hip joint, 224
age, 197, 198, 225
at incipiency table of, 22
deformity in, 248
excision, 289, 291
functional results, 259, 297, 298
mortality, 295
retardation of growth, tables of, 238, 239
sex, 197, 225
side affected, 197, 225
of shoulder joint, 348, 349
of wrist joint, 354
of weak foot, 512
Sterno-mastoid muscle, hæmatoma of, 477
Stiffness of vertebral column, see Spondylitis Deformans, 111
Strain of the tendo Achillis, 547
Symptoms of abscess in Pott's disease, 87
of achillo-bursitis, 545
posterior, 547
of actinomycosis of spine, 108
of acquired genu recurvatum, 333
talipes calcaneus, 618
equinus, 612
of acromegalia, 372
of acute anterior poliomyelitis, 442
torticollis, 481
of anchylosis, 218
of anterior bow leg, 429
metatarsalgia, 538
of arthritis deformans at hip, 302
of bilateral dislocation at hip joint, 380
of bow leg, 423
of bursæ at hip, 302
at knee, 326
at shoulder, 359
of calcaneo-bursitis, 547
of Charcot's disease, 217
of club hand, 434
of congenital club foot, 572
dislocation of hip joint, 378
of shoulder joint, 430
of coxa vara, 394
of cubitus valgus, 433
varus, 433
of displacement of peronei tendons, 555
of Dupuytren's contraction, 439
of elevation of scapula, 185
of elongation of ligamentum patellæ, 331
of epiphysitis, 212
at hip joint, 301
of erythromelalgia, 548
of extra-articular disease at hip joint, 301
of flat chest, 186
of fœtal rhachitis, 367
Symptoms of funnel chest, 187
of genu recurvatum, acquired, 332
congenital, 328
varum, 425
of gonorrhœal arthritis, 208
of spine, 110
of hæmarthrosis, 217
of hæmophilia, 210
of hallux rigidus, 548
valgus, 553
of hammer toe, 554
of hereditary ataxia, 469
of hollow foot, 535
of hysterical club foot, 470
hip, 470
scoliosis, 471
spine, 115
of infantile scorbutus, 368
of infectious arthritis, 210
of injury of hip, 300
of knee, 324
of spine, 108
of internal derangement of knee, 327
of knock knee, 412
of kyphosis, 182
of late rickets, 366
of lateral curvature of spine, 141
of lordosis, 184
of malignant disease of spine, 107
of mallet finger, 438
of neuritis, 469
of neurotic joints, 471
spine, 115
of obstetrical paralysis, 431
of osteo-arthritis, 215
of knee joint, 325
of osteomalacia, 369
of osteomyelitis of spine, 108
of osteitis deformans, 114, 370
of paralysis, 442, 460
in Pott's disease, 95
of periarthritis of shoulder, 358
of pigeon chest, 186
of plantar neuralgia, 548
of Pott's paraplegia, 95
of prepatellar bursitis, 325
of pretibial bursitis, 326
of recurrent dislocation of shoulder, 432
of rhachitis, 362
of sacro-iliac disease, 117
of sciatic scoliosis, 117
of scorbutus, 217, 367
of slipping patella, 330
of snapping knee, 331
of spastic paralysis, 459
of spina ventosa, 356
of spondylitis deformans, 112
of spondylolisthesis, 116
of sprain of ankle, 342
of syphilitic disease of joints, 206
of syphilis of spine, 107
of talipes acquired, 609
congenital, 560
of teno-synovitis, 346
of torticollis, acquired, 479

Symptoms of torticollis, congenital, 475
spasmodic, 486
spastic, 480
of trigger finger, 438
of tuberculous disease of ankle joint, 336
of elbow joint, 351
of hip joint, 225
of knee joint, 306
of shoulder joint, 349
of spine, 24
of tarsus, 341
of wrist joint, 355
of unilateral coxa vara, 396
of weak foot, 513
of webbed fingers, 437
Synovial disease of joints, statistics of, 201
in tuberculous disease of knee joint, 318
treatment of, 318
carbolic acid in, 318
chloride of zinc in, 318
iodoform injection in, 319
venous stasis in, 319
Synovitis, 324
chronic, 324
treatment of, 324
aspiration in, 325
braces in, 325
treatment of, 324
plaster strapping in, 324
Syphilitic disease of joints, 206
acquired, 207
hereditary, 206
later manifestations in, 207
pseudo-paralysis in, 206
spina ventosa in, 207
treatment of, 208
of spine, 107
diagnosis of, 107

TABLE of age at incipiency tuberculous disease ankle joint, 335
elbow joint, 351
hip joint, 225
knee joint, 306
of shoulder joint, 349
of spine, 22
of wrist joint, 355
of patients treated at Tübingen for tuberculous disease ankle joint, 336
Kingsley's, 244
Lovett's, 242
of statistics acquired torticollis, 481
Table of anterior poliomyelitis, 441, 442
of congenital dislocation of hip joint, 374
of coxa vara, 395
of genu valgum, 406
varum, 405
of lateral curvature of spine, 130
of normal development, 190
of talipes, 567, 568
Talipes, 560
acquired, 609
etiology of, 609
development of deformity in, 609
differential diagnosis in, 610
statistics of, 566
foot affected, 567
relative frequency, different forms, 568
sex, 567
arcuatus, see Hollow Foot, 534
calcaneo-valgus, 622
statistics of, 605
treatment of, 622
-varus, 622
statistics of, 605
treatment of, 622
calcaneus, acquired, 616
astragalectomy for, 620
development of deformity of, 617
symptoms of, 618
treatment of, 618
operative, 619
Willett's operation for, 619
congenital, 604
statistics of, 604
treatment of, 604
cavus, see Hollow Foot, 534
statistics of, 605
congenital, 562
etiology of, 563
statistics of, 566
foot affected, 567
relative frequency different forms, 567
sex, 567
equino-cavus, statistics of, 605
valgus, acquired, 623
associated with congenital absence of fibula, 606
etiology of, 607
statistics of, 606
treatment of, 607
statistics of, 605
treatment of, 623
varus, 569
acquired, 623
treatment of, 623
cuneiform osteotomy in, 623
equinus, acquired, 611
etiology of, 612
immediate correction of deformity of, 614

Talipes, equinus, Thomas wrench for, 614
effect of, 615
prognosis of, 613
symptoms of, 612
treatment of, 613
Shaffer extension brace in, 614
congenital, 604
statistics of, 604
etiology of, 562
paralytic, tendon transplantation for the relief of, 624
other methods, 625
Parish's operation, 625
plantaris, see Hollow Foot, 534
Talipes and spina bifida, 608
valgo-cavus, statistics of, 605
valgus, congenital, 605
statistics of, 605
varieties of, 560
varus associated congenital absence tibia, 607
prognosis of, 607
statistics of, 607
treatment of, 607
congenital, 603
Tarsus, tuberculous disease of, 341
Taylor back brace, 63
foot brace, 581, 582
Taylor hip braces, 256, 279, 281
Tendo Achillis, division of, in treatment of club foot, 592
strain of, 547
Tendon splicing, 629
transplantation for relief of paralytic talipes, 624
Nicoladoni's operation, 624
Parish's operation, 625
other methods of, 625
in treatment of anterior poliomyelitis, 456, see Talipes
Teno-synovitis, 345
at ankle, 346
symptoms of, 346
treatment of, 347
tuberculous, 347
at wrist, 360
Tenotomy, subcutaneous, in treatment of talipes, 591
Teschner's exercises in treatment of lateral curvature of spine, 151
Thomas brace, in treatment of genu valgum, 420
tuberculous disease ankle joint, 340
collar, 79
hip brace in treatment sacro-iliac disease, 119
knee brace in treatment of tuberculous disease of knee joint, 314
Thomas knee brace, description of, 315
method forcible correction of deformity of club foot, 595
treatment tuberculous disease, hip joint, 260
hip splint, 261
wrench in treatment of talipes, 595, 614
Tibialis anticus, division of, in treatment of club foot, 593
posticus, division of, in treatment of club foot, 593
Toes, over-lapping, 555
Torticollis, 474
acquired, 479
statistics of, 481
table of, 481
varieties of, 479
acute, diagnosis of, 482
differential, 483
etiology of, 479
spastic, 480
causes of, 480
symptoms of, 481
congenital, 475
deformity of, 475
etiology of, 477
hæmatoma of sterno-mastoid muscle in, 477
pathology of, 478
secondary distortions of, 476
following diphtheritic paralysis, 491
ocular, 491
paralytic, 490
posterior, 491
psychical, 491
rhachitic, 491
spasmodic, 486
etiology of, 487
pathology of, 487
prognosis of, 487
statistics of, 487
treatment of, 487
operation in, 488
statistics of, 474
treatment of, 483
correction of deformity in, 484
by subcutaneous tenotomy, 484
open operation, 484
Traction hip brace, 251
application of, 254
Traumatic coxa vara, 402
diagnosis of, 402
treatment of, 402
separation of epiphysis of head of femur, 404
spondylitis, 109
valgus, 624
Treatment of abscess in Pott's disease, 89
in tuberculous disease of hip joint, 287
of knee joint, 318
of achillo-bursitis, 546
posterior, 547
of actinomycosis of spine, 108

Treatment of acquired genu recurvatum, 333
of luxation of clavicle. 188
of talipes calcaneus, 618
of equino-valgus, 623
-varus, 623
of equinus, 613
of valgus, 624
of varus, 624
of acute anterior poliomyelitis, 450
of torticollis, 483
of anchylosis, 219
of anterior bow leg, 429
of metatarsalgia, 542
of arthritis following infectious disease, 211
of spine, 111
deformans at hip, 303
of bilateral dislocation of hip joint, 382
of bow leg, 426
of bursæ at hip, 302
of knee, 326
of shoulder, 359
of calcaneo-bursitis, 547
of Charcot's disease, 218
of club hand, 436
of congenital absence of fibula, 607
of radius, 436
of ribs, 188
of tibia, 607
calcaneus, 604
club foot, 572
contraction of fingers, 437
at knee, 332
defect of pectoral muscles, 188
deficiencies of the foot, 608
dislocation of hip joint, 382
of shoulder, 430
elevation of scapula, 186
torticollis. 483
of coxa vara, 399
unilateral, 400
bilateral, 401
of displacement of peronei tendons, 556
of double tuberculous disease of hip joints, 284
of Dupuytren's contraction, 439
of elongation of ligamentum patellæ, 331
of epiphysitis, 212, 300
at hip, 301
of extra-articular disease at hip joint, 301
of flat chest, 186
of fœtal rhachitis, 367
of funnel chest, 188
of functional affections of joints, 472
of genu recurvatum, acquired, 333
congenital, 329
valgum, 417
varum, 426
of gonorrhœal arthritis, 210
of spine, 110
of hæmarthrosis, 217
Treatment of hæmophilia, 217
of hallux rigidus, 549
valgus, 553
varus, 551
of hammer toe, 554
of hemiplegia, 463
of hereditary ataxia, 469
of hollow foot, 535
of hysterical club foot, 471
hip, 471
scoliosis, 471
spine, 116
of infantile scorbutus, 368
of infectious arthritis, 210
of knee joint, 325
of injury of hip, 300
knee, 324
spine, 109
of internal derangement of knee, 327
of knock knee, 412
of kyphosis, 184
of lateral curvature of the spine, 147
of lordosis, 185
of malignant disease of spine, 108
of mallet finger, 438
of neuritis, 469
of neurotic joints, 471
of neurotic spine, 115
of obstetrical paralysis, 431
of osteo-arthritis, 215
at hip joint, 302
at knee joint, 325
-arthropathy, 371
of osteomalacia, 369
in childhood, 370
of osteomyelitis of spine, 108
of osteitis deformans, 370
of pain in lower part of back, 116
of paralysis, 450, 464, 468
in tuberculous disease of spine, 97
of paraplegia, 97, 464
of periarthritis of shoulder, 358
of pigeon chest, 187
of plantar neuralgia, 548
of prepatellar bursitis, 325
of pretibial bursitis, 326
of pseudo-hypertrophic muscular paralysis, 468
of recurrent dislocation of shoulder, 432
of rhachitis, 365
fœtal, 367
of rhachitic distortions, 365
of rudimentary or absent patella, 329
of sacro-iliac disease, 118
of sciatic scoliosis, 117
of scorbutus, 217, 368
of sinuses in tuberculous disease of hip joint, 289
of slipping patella, 330
of snapping knee, 332
of spasmodic torticollis, 487
of spastic paralysis, 463
torticollis, 486
of spina ventosa, 357
of spondylitis deformans, 114

Treatment of spondylolisthesis, 117
of sprain of ankle, 343
chronic, 345
of wrist, 359
chronic, 359
of subluxation of wrist, 434
of synovial tuberculous disease of knee joint, 318
of synovitis, 324
chronic, 324
of syphilitic disease of joints, acquired, 208
hereditary, 208
of syphilis of spine, 107
of talipes acquired, 613
calcaneus, 618
calcaneo-valgus, 622
-varus, 622
cavus, see Hollow Foot, 535
equinus, 613
equino-valgus, 624
-varus, 624
planus, see Weak Foot, 521
valgus, 624
varus, 624
congenital, 573
calcaneus, 604
calcaneo-valgus, 605
-varus, 605
cavus, 605
equinus, 604
equino-valgus, 605
-varus, 605
valgus, 605
varus, 604
of teno-synovitis, 347
of ankle, 347
of wrist, 360
of torticollis acquired, 483
congenital, 483
chronic, 483
spasmodic, 487
spastic, 486
of traumatic coxa vara, 402
separation of the epiphysis of head of femur, 403
of trigger finger, 438
of tuberculous disease of ankle joint, 339
of elbow joint, 352
of hip joint, 249
of knee joint, 311
of shoulder joint, 350
of spine, 58
of tarsus, 342
of wrist joint, 355
joint disease, 204
of typhoid spine, 110
of weak foot, 521
rigid, 527
of webbed fingers, 437
Trigger finger, 438
etiology of, 438
treatment of, 438
Trunk, deformities of, in anterior poliomyelitis, 448
Tuberculosis, arborescent synovial, 201
latent, 194
Tuberculous arthritis, acute, 212
disease of ankle joint, 334
abscess in, 334
situation of disease, 335
deformity of, 336
etiology of, 335
statistics of, 335
age at incipiency, table of, 335
age of patients treated at Tübingen, table of, 336
frequency of, 334
statistics of, 334
pathology of, 334
physical examination in, 337
prognosis in, 341
statistics, final results, 341
symptoms of, 336
treatment of, 339
operative, 340
reduction of deformity in, 339
by plaster bandage, 339
Thomas brace in, 340
removal of astragalus in, 340
description of operation, 340
bones and joints, 194
of elbow joint, 351
excision of elbow in, 353
description of operation, 354
final results of, 354
pathology of, 351
prognosis of, 353
statistics, age at incipiency, table of, 351
situation of, 351
symptoms of, 351
treatment of, 352
operative, 353
reduction of deformity in, 352
Thomas method of, 352
general dissemination of, 203
by operation, 203
of hip joint, 221
abscess in, 285
frequency of, 285
significance of, 286
treatment of, 287
by aspiration, 288

Tuberculous disease of hip joint, treatment by incision, 288
by injection, 288
actual lengthening in, 238
shortening in, 236
causes of, 236
in the adult, 285
amputation in, 292
atrophy in, 234
Brackett's observations on, 235
causes of, 234
theory of Saborin, 234
theory of Vulpian and Charcot, 234
changes in contour of the hip, 234
in combination, 284
deformities incidental to, 299
diagnosis of, 244
Röntgen ray in, 247
distortions of, 228
apparent lengthening in, 229
shortening in, 230
explanation of, 229
mechanics of, 232
double, 283
treatment of, 284
examination in, method of, 240
physical, 240
excision of hip in, 290
functional results after, 290, 292
statistics of, 289, 291
exploratory operations in, 289
etiology of, 224
general symptoms of, 240
debility, 240
fever, 240
history of, 240
in infancy, 285
local signs of, 244
measurements in, 241
method of estimating degree of distortion in, 242
Kingsley's table, 244
Lovett's table, 242
of recording case in, 247

Tuberculous disease of hip joint, other deformities incidental to, 299
pathology of, 221
changes in the joint, 223
situation of disease, 223
prognosis in, 294
functional results of, 297
statistics of, 297, 298
mortality, 295
statistics of, 295
progression of symptoms in, 249
reduction of deformity of, 256, 258
by osteotomy, 293
by plaster bandage, 265
by Thomas splint, 263
by traction brace, 256
by weight and pulley, 268
relative frequency of, 196, 197, 224
retardation of growth in, 238
tables of, 238, 239
sinuses in, treatment of, 289
statistics of, 224
age, 197, 198, 225
age at incipiency, table of, 225
of deformity in, 248
sex, 197, 225
side affected, 197, 225
symptoms of, 225
limp, 226
night cry, 226
pain, 226
reflex muscular spasm, 227
stiffness, 227
treatment of, 249
Bradford frame in, 271
chair for, 278
during convalescence, 280
splints for, 280, 281
fixation in, 272
"high shoe" in, 254
Judson's brace in, 255
lateral traction in, 271

Tuberculous disease of hip joint, treatment, long hip brace in, 276, 277
mechanical principles of, 251
perineal bands in, 254
Phelps' hip brace in, 278
plaster spica bandage in, 266
application of, 266
reduction of deformity in, 256, 263, 268, 293
"stilting" in, 273
Taylor's braces for, 276, 279
Thomas' splint in, 261
description of, 261
modification of, 264
traction brace, varieties of, 252
relative efficiency of, 257
traction brace in, 251
traction, splinting, stilting, combined in, 273
traction straps in, 253
of joints, synovial disease, 201
statistics of, 201
of knee joint, 304
abscess in, 318
statistics of, 318
treatment of, 318
by aspiration, 318
by incision, 318
actual lengthening in, 310
shortening in, 310
amputation in, 321
arthrectomy in, 319
advantages of, 319
results of, 319
statistics of, 319
table of shortening in, 320
deformity in, 322
statistics of, 322
diagnosis of, 310
differential, 310, 311
etiology of, 305
excision in, 320
description of operation, 320
mechanical support after, 321
results of, 321
selection of cases for, 320
Tuberculous disease of knee joint, functional results of, 322
statistics of, 322
general conclusions on, 323
mortality of, 322, 323
operations for relief, final deformity of, 321
pathology of, 304
primary distortions in, 307
prognosis of, 321
statistics of, 321
retardation of growth in, 310
statistics of, 310
secondary deformities of, 308
statistics of, 310
situation of, 304
statistics of, 304, 305, 306
age, 305
sex, 305
age at incipiency, table of, 306
symptoms of, 306
synovial disease in, 318
treatment of, 318
chloride of zinc in, 318
carbolic acid in, 205, 318
iodoform injection in, 319
venous stasis in, 205
treatment of, 311
conservative, 312
during convalescence, 317
forcible correction in, 314
mechanical, 314
Thomas knee brace in, 314
description of, 315
the caliper brace in, 317
description of, 317
reduction of deformity in, 312
by the plaster bandage, 313
by traction, 313

Tuberculous disease of knee joint, reduction of, by the Billroth splint, 313
of shoulder joint, 348
abscess in, 350
pathology of, 348
prognosis of, 350
results of, 350
statistics, age at incipiency, table of, 349
statistics of frequency of, 348
symptoms of, 349
treatment of, 350
operative, 350
of spine, 17
at cervico-dorsal junction, 53
differential diagnosis, 54
complications of, 87
abscess, 87
in different regions, 88
treatment of, 89
deformity of, 17
effect of, 17
diagnosis in general, 57
etiology of, 21
forcible correction, deformity of, 101
Calot's operation, 101
statistics, results of, 102
selection of cases for, 102
gradual correction, deformity of, 104
Metzger-Goldthwait apparatus for, 105
history of, 33
local paralysis in, 98
lower cervical region, 52
lower region of, 35
characteristic attitude in, 35
differential diagnosis of, 41
increased lordosis in, 35
lateral inclination of body in, 38
location of pain in, 38
pelvic abscess in, 40
treatment of, 90
psoas contraction in, 36
lumbar, peculiarities of in infancy, 44
middle region, 46
abscess in, 49
diagnosis of, 50
Tuberculous disease of spine, middle region, symptoms of, 48
treatment of, 90
paralysis in, 93
duration of, 95
statistics of frequency of, 93
liability to, in different regions, 94
prognosis of, 95
time of onset of, 95
symptoms of, 95
treatment of, 97
operative, 98
duration of, 99
pathology of, 18
physical signs of, 34
principles of treatment of, 80
prognosis of, 24
rational signs of, 32
record of, 57
recurrence of, 100
regional examination in, 35
secondary deformities of, 100
statistics of, 21
age, 22
frequency, 21
sex, 22
situation, 22
symptoms of, 24
diagnostic, 25
general, 29
secondary, 28
treatment of, 58
anterior shoulder brace in, 66
of the different regions, special indications for, 83
horizontal fixation in, 60
apparatus for, 60
Bradford frame, 60
application of, 62
Phelps' bed, 60
reclination-gypsbettes, Lorenz, for, 60
wire cuirasse, 60
jury mast in, 73
mechanical, general principles of, 58
plaster jacket in, 70
principles of, 80
recumbency, indications for, 81
Taylor brace in, 63
measurements for, 64
application of, 64

Tuberculous disease of spine, middle region, Taylor head support in, 69
upper region, 51
symptoms of, 52
Thomas collar in, 79
sub-astragaloid joint, 339
diagnosis, 339
differential, 339
tarsus, 341
disease of individual bones, statistics of, 341
primary disease astragaloscaphoid joint, 342
prognosis, 342
statistics of situation of, 341
treatment of, 342
wrist joint, 354
prognosis of, 355
statistics of, 354
age at incipiency, table of, 355
symptoms of, 345
treatment of, 355
caries sicca in, 201
connective tissue in, 200
deposit of fibrin in, 200
diseases predisposing to, 195
etiology of, 194
extra-articular, 199
abscess in, 199
local predisposition to, 195
influence of injury in, 195
osteophytes in, 200
pathology of, 198
perforation of joint in, 200
predisposition to, 194
hereditary, 194
acquired, 194
prognosis of, 202
repair in, 202
rice bodies in, 201
seat of, 196
secondary abscess in, 200
secondary changes in, 200
septic infection in, 202
statistics of, 196
age, 197
distribution, 196
relative frequency, 197
statistics of results of, 203
sex, 197
side affected, 197
treatment of, 204
by drugs, 204
by local application, 204
carbolic acid, 205
iodoform, 204
venous stasis, 205
"white swelling" in, 201
teno-synovitis, 347
Tumor albus, see Tuberculous Disease of Knee Joint, 304
Typhoid fever, arthritis following, 211
Typhoid spine, 110
treatment of, 110

UNILATERAL coxa vara, 396
dislocation of hip, 378
genu valgum, 415
Upper extremity, deformities of, in anterior poliomyelitis, 447

VALGUS, traumatic, 624
Vertebræ, absence of, 186
Vertebral column, stiffness of, see Spondylitis Deformans, 111
Volkmann's seat in lateral curvature of spine, 180

WEAK foot, 507
anatomy of, 508
in childhood, 519
out and in toeing as symptoms of, 519
diagnosis of, 514
etiology of, 511
extreme types of, 517
pathology of, 511
rigid, 527
treatment of, 527
adjuncts in, 532
plaster strapping in, 532
forcible over-correction in, 527
systematic manipulation in, 527
Thomas, 532
symptoms of, 513
treatment of, 521
attitudes in, 522
brace in, 525
exercises in, 523
treatment, operative, 532
the shoe in, 521
support in, 523
varieties of, 516
Webbed fingers, 437
etiology of, 437
treatment of, 437
Weight, table of, 190
White swelling, see tuberculous disease of knee joint, 304
Willett's operation for calcaneus, 619
Wire cuirasse in treatment of Pott's disease, 60
Wolff's law, 190
method of correction of confirmed club foot, 593
treatment of genu valgum, 423
Wrist, acute teno-synovitis at, 360
congenital deformities at, 434
joint, tuberculous disease of, 354
sprain of, 359
chronic, 359
treatment of, 359
treatment of, 359
subluxation of, 434
etiology of, 434
treatment of, 434
Wry neck, see torticollis, 474

Apr 22 1901

APR 11 1901

LIBRARY OF CONGRESS
0 021 067 547 4